Unit I: Basic Concepts of Chemistry

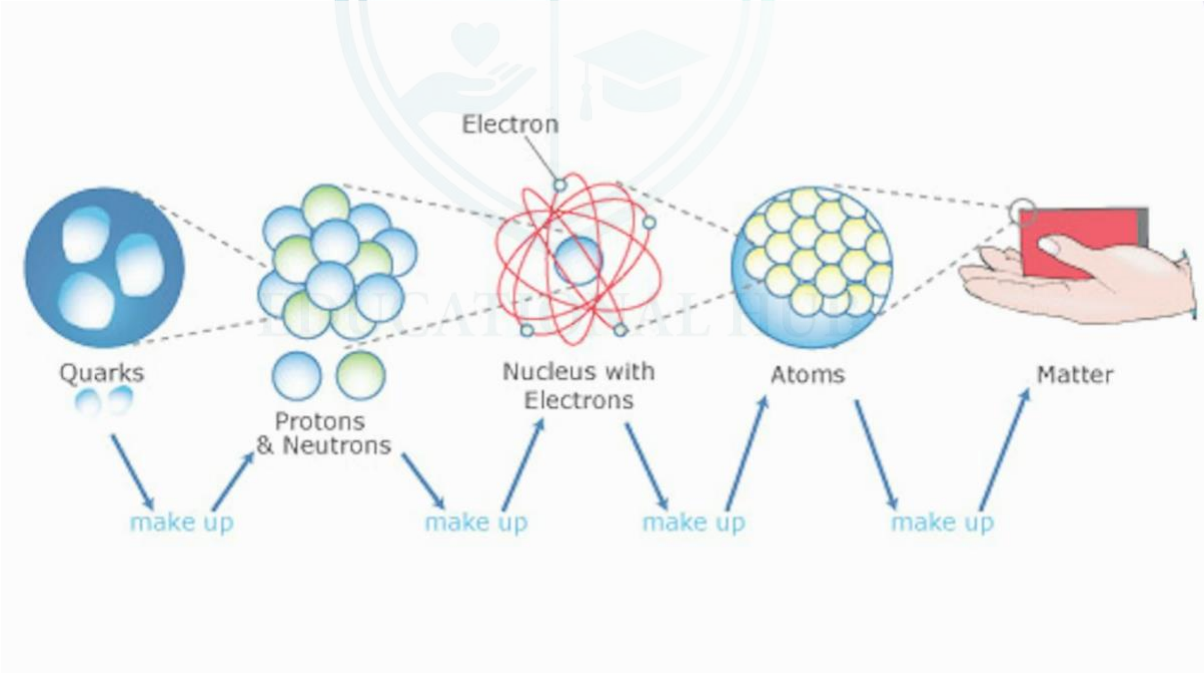
Unit Objectives:

1. Review the basic concepts of matter and its structure.
2. Review elements, mixtures, and compounds.
3. Appreciate the importance of ions and electrolytes in the body.
4. Describe chemical bonding, its types (Intramolecular and intermolecular Bonding), and its properties and importance.
5. Describe the types of chemical reactions with emphasis on redox reactions.
6. Describe the chemical nature of acid, base, pH, and blood buffers including their properties, roles, and importance in the living system.

1. Matter and Its Structure

Matter is anything that has mass and occupies space. In the human body, matter exists primarily as solids (bones), liquids (blood/plasma), and gases (oxygen/carbon dioxide).

- **Atomic Structure:** The atom is the smallest unit of an element. It consists of a nucleus containing **protons** (+) and **neutrons** (neutral), surrounded by **electrons** (-) in specific energy levels or shells.
- **Significance:** Understanding atomic structure is vital for grasping how drugs interact at a molecular level and how radiation therapy affects cellular DNA.



2. Elements, Mixtures, and Compounds

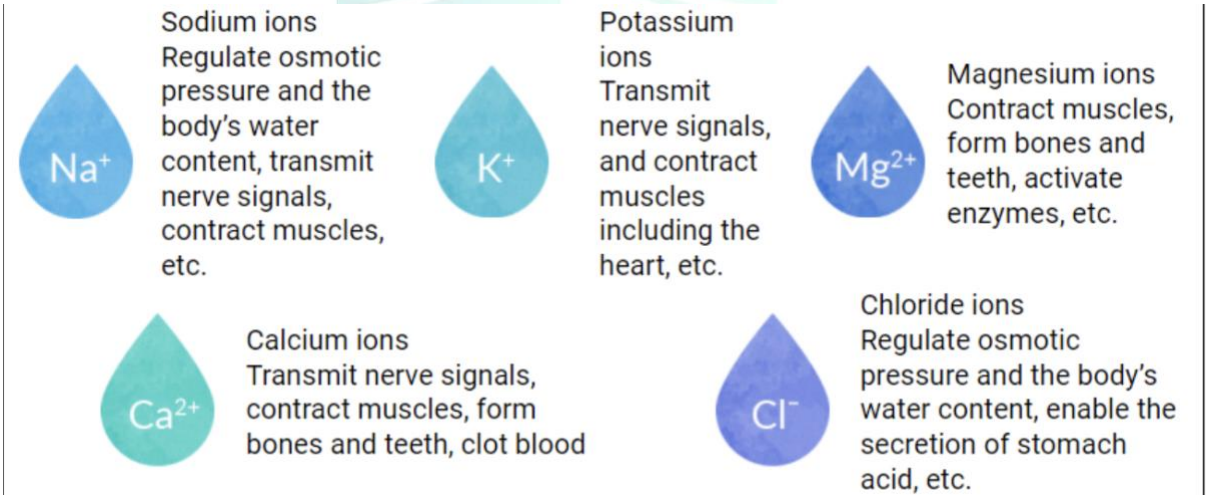
- **Elements:** Pure substances consisting of one type of atom (e.g., Oxygen, Carbon, Hydrogen).

- **Compounds:** Substances formed when two or more elements are chemically bonded (e.g., H2O, NaCl).
- **Mixtures:** Physical combinations of substances that are not chemically bonded.
    - **Homogeneous (Solutions):** Like IV saline, where the solute is evenly distributed.
    - **Heterogeneous (Suspensions):** Like whole blood, where cells will eventually settle if not kept in motion.

3. Ions and Electrolytes

In nursing, electrolytes are the "sparks" of the body. An **ion** is an atom that has gained or lost electrons, acquiring a charge.

- **Cations:** Positively charged (e.g., Na+, K+, Ca2+).
- **Anions:** Negatively charged (e.g., Cl−, HCO3−).
- **Clinical Importance:** Electrolytes conduct electrical impulses in the heart and muscles, maintain osmotic pressure, and regulate hydration. Imbalances (e.g., hypokalemia) can lead to life-threatening arrhythmias.



4. Chemical Bonding

Chemical bonds are the forces holding atoms together.

Intramolecular Bonding (Within a molecule)

- **Ionic Bonds:** Electrons are transferred from one atom to another (e.g., NaCl).
- **Covalent Bonds:** Electrons are shared between atoms (e.g., the bonds in glucose or proteins). These are generally stronger and more stable in the aqueous environment of the body.

Intermolecular Bonding (Between molecules)

- **Hydrogen Bonds:** Weak attractions between polar molecules.

- **Importance:** These bonds give water its unique properties and hold the two strands of the DNA double helix together, allowing them to "unzip" for replication.

5. Chemical Reactions and Redox

Chemical reactions involve the breaking and forming of bonds.

- **Synthesis (Anabolism):** Building complex molecules (e.g., protein synthesis).
- **Decomposition (Catabolism):** Breaking down molecules (e.g., digestion).
- **Redox (Oxidation-Reduction):** Reactions where electrons are transferred.
    - **Oxidation:** Loss of electrons.
    - **Reduction:** Gain of electrons.
    - **Role:** These reactions are the cornerstone of cellular respiration, where energy (ATP) is harvested from nutrients.

6. Acids, Bases, pH, and Blood Buffers

The body is extremely sensitive to changes in acidity.

- **Acids:** Substances that release hydrogen ions (H+) in solution.
- **Bases:** Substances that accept H+ ions or release OH− ions.
- **pH Scale:** Measures the concentration of H+. The physiological pH of arterial blood is strictly maintained between **7.35 and 7.45**.

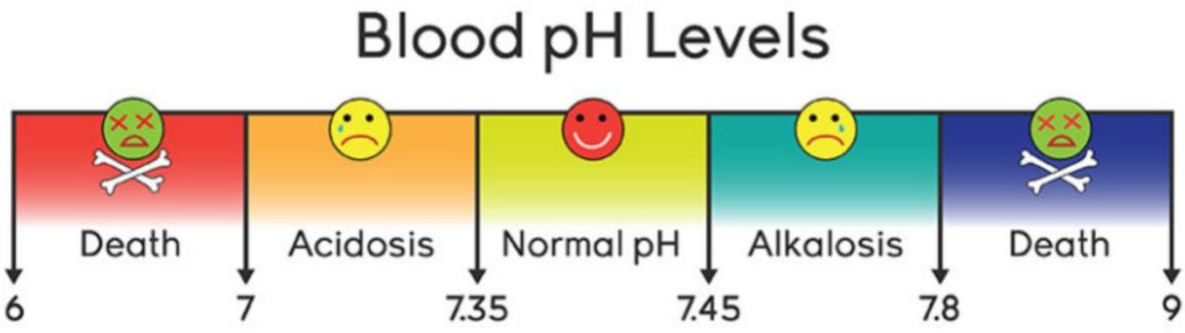
Blood Buffers

Buffers are chemicals that resist abrupt changes in pH by binding or releasing H+ ions.

- **Primary System:** The Carbonic Acid-Bicarbonate Buffer System.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

- **Clinical Importance:** When a patient is in respiratory or metabolic acidosis/alkalosis, these buffer systems (along with the lungs and kidneys) work to restore homeostasis.



MCQs: Basic Concepts of Chemistry

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Which subatomic particle determines the identity of an element?	Electron	Neutron	**Proton**	Positron	C
2	A physical combination of substances that can be separated easily is a:	Compound	Molecule	**Mixture**	Element	C
3	Which of the following is the major **intracellular** cation ?	Sodium	**Potassium**	Chloride	Bicarbonate	B
4	The bond formed by the complete **transfer** of electrons is:	Covalent	Hydrogen	**Ionic**	Metallic	C
5	In a Redox reaction, **Oxidation** refers to:	Gain of electrons	**Loss of electrons**	Gain of protons	Loss of neutrons	B
6	The normal pH range of arterial blood is:	7.00 – 7.15	**7.35 – 7.45**	7.55 – 7.65	6.85 – 6.95	B
7	Which bond holds the two strands of **DNA**together?	Ionic	Peptide	**Hydrogen**	Glycosidic	C
8	A solution with a **pH of 3.0** is considered:	Strongly Basic	Weakly Basic	Neutral	**Strongly Acidic**	D
9	Which of these is a "**homogenous**" mixture?	Whole blood	**Normal Saline**	Oil and water	Milk	B
10	The process of **building** complex molecules (synthesis) is:	Catabolism	Oxidation	**Anabolism**	Diffusion	C
11	A negatively charged ion is called a/an:	Cation	Isotope	**Anion**	Molecule	C
12	Major buffer system in the **Extracellular Fluid (ECF)** is:	Phosphate	Protein	Hemoglobin	**Bicarbonate**	D
13	If pH decreases, what happens to the H^+concentration?	**It increases**	It decreases	Stays the same	Turns into OH^-	A
14	Which of the following is a **compound**?	Oxygen	**Water**	Nitrogen	Gold	B
15	Electrolytes are essential because they:	Provide calories	**Carry impulses**	Store DNA	Build muscle	B
16	In the body, H_2CO_3 is the chemical formula for:	Bicarbonate	**Carbonic acid**	Carbon dioxide	Citric acid	B
17	Which bond involves the "**sharing**" of electron pairs?	Ionic	**Covalent**	Electrovalent	Polar Ionic	B

18	A patient with a blood **pH of 7.20** is in a state of:	Alkalosis	Homeostasis	**Acidosis**	Neutrality	**C**
19	Which of the following is a **trace element**?	Carbon	Hydrogen	**Iron**	Oxygen	**C**
20	Atoms are stable with **8 electrons** in valence shell due to:	Duplet Rule	**Octet Rule**	Redox Rule	Bohr's Rule	**B**

Short Questions (SQs) with Answers

Q1: Define Matter and list its three physical states found in the human body.

- **Answer:** Matter is anything that has mass and takes up space. In the body, it exists as **Solid** (bones/teeth), **Liquid**(blood/plasma), and **Gas** (oxygen/carbon dioxide in lungs).

Q2: Differentiate between a Compound and a Mixture.

- **Answer:** A **Compound** consists of atoms of different elements chemically bonded in a fixed ratio (e.g., H2O). A **Mixture** consists of substances physically blended together but not chemically bonded (e.g., salt water), and they can be separated by physical means.

Q3: Why are Electrolytes clinically significant for nurses?

- **Answer:** Electrolytes (like Na+, K+, Ca2+) are essential for maintaining osmotic pressure (fluid balance), conducting nerve impulses, and allowing muscle contractions (including the heart). Nurses must monitor them to prevent complications like arrhythmias or seizures.

Q4: Explain the difference between Ionic and Covalent bonding.

- **Answer: Ionic bonding** occurs when one atom "donates" an electron to another, creating charged ions that attract (e.g., NaCl). **Covalent bonding** occurs when atoms "share" electrons to achieve stability (e.g., CH4).

Q5: What is a Redox reaction?

- **Answer:** A Redox (Reduction-Oxidation) reaction involves the transfer of electrons between two species. Oxidation is the loss of electrons, while Reduction is the gain of electrons ("OIL RIG").

Q6: Define pH and state its mathematical relationship to Hydrogen ions.

- **Answer:** pH is a measure of the acidity or alkalinity of a solution. It is defined as the negative logarithm of the hydrogen ion concentration ($pH = -\log[H^+]$). As H+ increases, pH decreases (becomes more acidic).

Q7: Briefly describe the role of a "Buffer" in the living system.

- **Answer:** A buffer is a chemical system that prevents radical changes in fluid pH by absorbing excess H^+ ions when the environment becomes too acidic or releasing H^+ ions when it becomes too alkaline.

Q8: What is the clinical significance of the Bicarbonate Buffer System?

- **Answer:** It is the primary buffer for blood. It allows the body to maintain a stable pH by converting strong acids/bases into weak ones, with the lungs regulating CO_2 and the kidneys regulating HCO_3^-.

Q9: Distinguish between Intramolecular and Intermolecular forces.

- **Answer: Intramolecular forces** are the strong bonds *within* a molecule (Covalent/Ionic) that hold the atoms together. **Intermolecular forces** are the weaker attractions *between* molecules (like Hydrogen bonds) that determine physical properties like boiling point.

Q10: What is the importance of "Hydrogen Bonding" in biological molecules?

- **Answer:** Hydrogen bonds provide the specific 3D shape of proteins and the double-helix structure of DNA. They also give water its high heat capacity, which helps in maintaining body temperature.

Unit II: Basic Concepts of Organic Chemistry

Unit Objectives:

1. Recognize the importance of organic compounds.
2. Compare properties of organic and inorganic compounds.
3. Understand the structure of organic compounds and its importance in terms of change in nature and properties of the chemicals.
4. Describe the classification of organic compounds.
5. Differentiate the types of hydrocarbons; saturated and unsaturated.

1. Importance of Organic Compounds

Organic compounds are the "building blocks of life." In a clinical setting, almost everything you administer or monitor is organic:

- **Biological Macromolecules:** Carbohydrates, lipids, proteins, and nucleic acids (DNA/RNA).
- **Pharmaceuticals:** Most drugs (e.g., Aspirin, Paracetamol, Antibiotics) are organic molecules.
- **Body Regulators:** Hormones (Steroids, Insulin) and Enzymes that catalyze metabolic reactions.

2. Organic vs. Inorganic Compounds

Understanding these differences helps in predicting how substances behave in the body or in a IV bag.

Property	Organic Compounds	Inorganic Compounds
Main Element	Always contains Carbon (C) and Hydrogen (H).	Usually does not contain Carbon (with exceptions like CO2).
Bonding	Primarily **Covalent** (sharing electrons).	Primarily **Ionic** (transferring electrons).
Solubility	Mostly soluble in non-polar solvents (fats).	Mostly soluble in water (polar).
Melting/Boiling Pt	Generally Low.	Generally High.
Reaction Speed	Slower (complex structures).	Faster (simple ions).

3. Structure and Properties

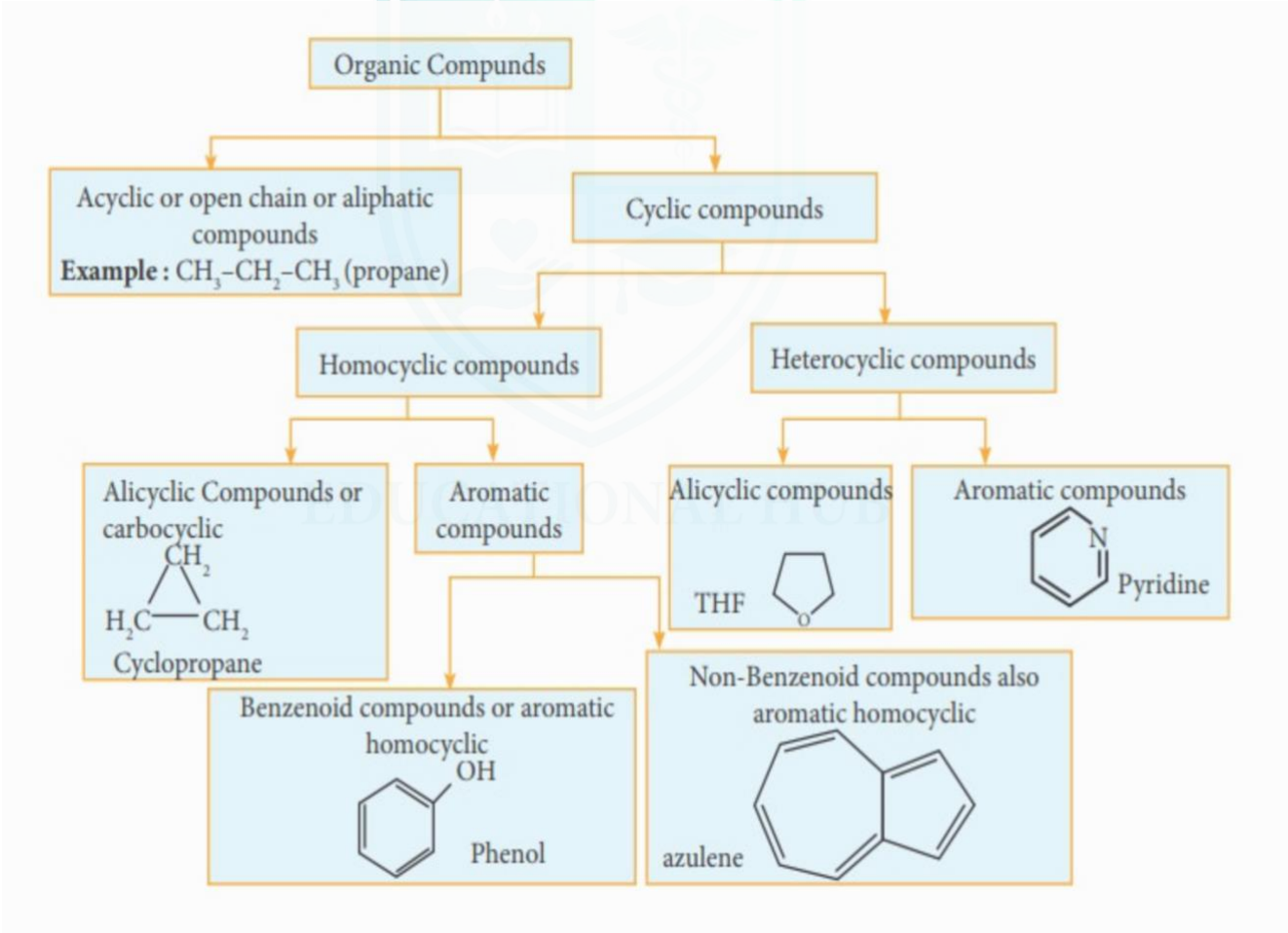
The structure of an organic molecule determines its function.

- **Functional Groups:** These are specific clusters of atoms (like −OH for alcohols or −COOH for acids) attached to the carbon skeleton.
- **The "Nature" Change:** If you change one atom in a structure, the property changes entirely. For example, changing a functional group can turn a medicinal drug into a toxic substance or change how a hormone interacts with a receptor.

4. Classification of Organic Compounds

Organic compounds are broadly classified based on their carbon skeleton:

1. **Acyclic (Open Chain):** Linear or branched chains of carbon atoms (e.g., Fatty acids).
2. **Cyclic (Closed Chain): * Homocyclic:** Rings made only of carbon (e.g., Benzene).
    - **Heterocyclic:** Rings containing carbon and other elements like Nitrogen or Oxygen (e.g., many DNA bases).



5. Hydrocarbons: Saturated vs. Unsaturated

Hydrocarbons are compounds containing only Carbon and Hydrogen. In nursing, this is most relevant when discussing **fats** and **respiratory gases**.

Feature	Saturated Hydrocarbons (Alkanes)	Unsaturated Hydrocarbons (Alkenes/Alkynes)
Bonds	Single bonds only (C−C).	Contains Double (C=C) or Triple bonds.
Hydrogen Content	Contains maximum possible Hydrogen.	Fewer Hydrogen atoms due to multiple bonds.
Reactivity	Less reactive (Stable).	More reactive.
Clinical Link	**Saturated Fats:** Usually solid at room temp (e.g., butter); linked to plaque in arteries.	**Unsaturated Fats:** Usually liquid (e.g., oils); often considered "heart-healthy."

Multiple Choice Questions (MCQs) - Unit II

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Organic chemistry is primarily the study of compounds containing:	Iron	**Carbon**	Calcium	Magnesium	**B**
2	Which type of bonding is most common in organic compounds?	Ionic	**Covalent**	Metallic	Electrovalent	**B**
3	Compared to inorganic compounds, organic compounds usually have:	**Low melting points**	High melting points	No melting point	High boiling points	**A**
4	Hydrocarbons containing only **single bonds** are called:	Alkenes	Alkynes	**Alkanes**	Aromatics	**C**

5	Which of the following is an **unsaturated**hydrocarbon?	Methane	Ethane	Propane	**Ethene**	**D**
6	"Saturated" means the molecule has the maximum number of:	Carbons	Electrons	**Hydrogens**	Oxygens	**C**
7	Which functional group is characteristic of **Alcohols**?	COOH	-CHO	**-OH**	NH_2	**C**
8	Organic compounds that form a **closed ring** are called:	Acyclic	Aliphatic	**Cyclic**	Open-chain	**C**
9	Inorganic compounds are generally soluble in:	Benzene	Ether	**Water**	Chloroform	**C**
10	Hydrocarbons with a **triple bond**($C\equiv C$) are known as:	Alkanes	Alkenes	**Alkynes**	Benzene	**C**
11	Most drugs and medications are classified as:	Inorganic	**Organic**	Metallic	Minerals	**B**
12	Saturated fats are typically found in what state at room temp?	Gas	Liquid	**Solid**	Plasma	**C**
13	The study of compounds *without* Carbon-Hydrogen bonds is:	**Inorganic Chem**	Organic Chem	Biochemistry	Genetics	**A**
14	Which of these is a biological organic compound?	NaCl	H_2O	**Glucose**	CO_2	**C**
15	Functional groups are important because they determine:	Color	Weight	**Chemical Properties**	Price	**C**
16	Compounds with the same formula but different structures are:	Isotopes	**Isomers**	Ions	Isobars	**B**
17	Which of these is a property of **Inorganic**compounds?	Slow reactions	Covalent bonds	**Ionic bonds**	Flammable	**C**
18	A hydrocarbon with a double bond ($C=C$) is:	Saturated	**Unsaturated**	Polymeric	Ionic	**B**
19	The simplest hydrocarbon is:	**Methane**	Ethane	Benzene	Glucose	**A**
20	Heterocyclic compounds contain rings with carbon and:	Only Hydrogen	**N, O, or S**	Only Carbon	No atoms	**B**

Unit II: Basic Concepts of Organic Chemistry — Short Questions (SQs)

Q1: Why is Carbon called the "Building Block of Life"? Answer: Carbon has the unique ability to form four (4) stable covalent bonds simultaneously. This allows it to create long chains and complex rings that form the foundation of essential biological molecules like DNA, proteins, and fats.

Q2: What is meant by Hydrocarbons? Answer: Hydrocarbons are organic compounds composed entirely of only two elements: **Carbon** and **Hydrogen**. Common examples include Methane (CH4) and Propane (C3H8).

Q3: What is the clear difference between Saturated and Unsaturated hydrocarbons? Answer: * Saturated: These contain only **single bonds** between carbon atoms (e.g., Alkanes).

- **Unsaturated:** These contain at least one **double** or **triple bond** between carbon atoms (e.g., Alkenes and Alkynes).

Q4: Explain the importance of Functional Groups. Answer: A functional group is a specific cluster of atoms that determines the chemical properties and reactions of an organic molecule. For example, adding an **−OH** group turns a molecule into an alcohol.

Q5: What is the difference in solubility between Organic and Inorganic compounds? Answer: Organic compounds are generally non-polar and dissolve in organic solvents (like ether or benzene), whereas Inorganic compounds are typically polar and dissolve easily in water (H2O).

Q6: What are Acyclic (Open-chain) compounds? Answer: These are compounds in which carbon atoms are joined in a straight or branched line and do not form a closed ring.

Q7: What is the role of Organic Chemistry in nursing practice? Answer: In nursing, medications (drugs), hormones, and nutrients (carbohydrates, lipids) are all organic. Understanding their structure makes it easier to comprehend pharmacology, drug interactions, and patient metabolism.

Q8: Define Cyclic (Closed-chain) compounds. Answer: These are organic compounds where carbon atoms link together to form one or more closed **Rings**.

Q9: Why are organic reactions slower than inorganic reactions? Answer: Organic compounds are held together by strong **covalent bonds**, which require more energy and time to break and reform. In contrast, inorganic reactions involve ions that react almost instantaneously.

Q10: What is the relationship between Saturated Fats and cardiac health? Answer: Excessive consumption of saturated fats (which are solid at room temperature) increases **LDL (bad cholesterol)** in the blood. This leads to plaque buildup in the arteries (atherosclerosis), increasing the risk of heart disease.

Unit III: Chemistry of Nutrients (Carbohydrates, Lipids, Proteins)

Unit Objectives:

1.Discuss carbohydrates including its general structure, classification and biological significance.
2.Compare the three major classes of carbohydrates that are monosaccharaides, disaccharides and polysaccharides.
3.Discuss lipids including its general structure, classification and, biological significance.
4.Explain the functions of phospholipids and steroids such as High 5.Density Lipoproteins (HDL) and Low Density Lipoproteins (LDL).
6.Discuss proteins including its general structure, classification, and biological significance.
7.Describe classification of proteins according to solubility, composition, functions and shape.
8.Explain the clinical significance of protein denaturation.
9.Discuss the foods containing carbohydrates, proteins, and lipids.

1. Carbohydrates: Structure, Classification, and Significance

Carbohydrates are organic compounds composed of Carbon, Hydrogen, and Oxygen, usually in a 1:2:1 ratio.Chemically, they are polyhydroxy aldehydes or ketones.

- **General Structure:** They consist of carbon chains with multiple hydroxyl (−OH) groups and a carbonyl group (C=O).
- **Biological Significance: * Primary Energy Source:** Provides 4 kcal/g.
    - **Protein Sparing Action:** Prevents the body from burning proteins for energy, allowing proteins to be used for tissue repair.
    - **CNS Fuel:** The brain relies almost exclusively on glucose.

2. Comparison of Carbohydrate Classes

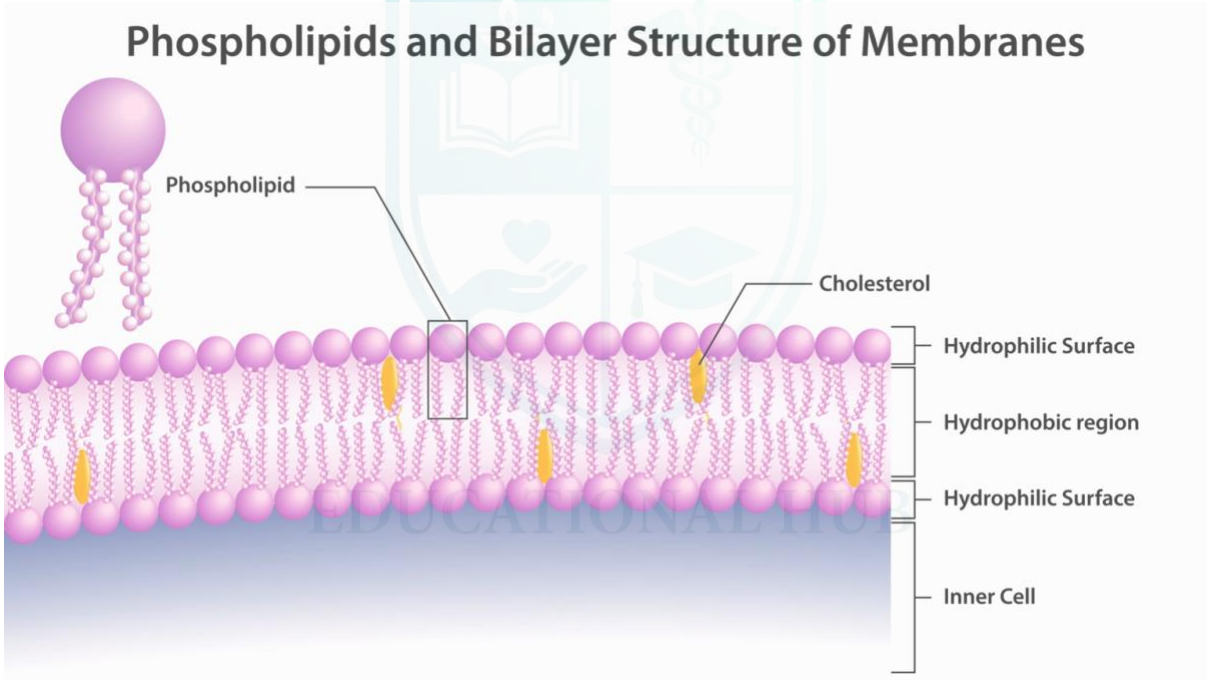
Feature	Monosaccharides	Disaccharides	Polysaccharides
Complexity	Simplest unit (Monomer).	Two sugar units.	Hundreds to thousands of units.
Solubility	Highly soluble in water.	Soluble in water.	Generally insoluble (e.g., Starch).
Examples	Glucose, Fructose, Galactose.	Sucrose, Lactose, Maltose.	Glycogen, Starch, Cellulose.

Digestion	Absorbed directly.	Must be broken into 2 units.	Requires prolonged digestion.

3. Lipids: Structure, Classification, and Significance

Lipids are hydrophobic (water-fearing) organic molecules.

- **General Structure:** Mainly composed of glycerol and fatty acid chains.
- **Classification:**
    1. **Simple Lipids:** Fats and waxes (Triglycerides).
    2. **Compound Lipids:** Phospholipids and Glycolipids.
    3. **Derived Lipids:** Steroids and Cholesterol.
- **Biological Significance:**
    - **Energy Storage:** Provides 9 kcal/g (highest energy yield).
    - **Insulation:** Subcutaneous fat maintains body temperature.
    - **Protection:** Cushions vital organs (kidneys, heart).



4. Phospholipids, HDL, and LDL

- **Phospholipids:** Major component of the **Cell Membrane**. They have a hydrophilic head and hydrophobic tail, forming a bilayer that regulates what enters/leaves the cell.
- **LDL (Low-Density Lipoprotein):** Known as **"Bad Cholesterol."** It transports cholesterol from the liver to the tissues. High levels lead to plaque buildup in arteries (Atherosclerosis).
- **HDL (High-Density Lipoprotein):** Known as **"Good Cholesterol."** It scavenges extra cholesterol from the blood and takes it back to the liver for excretion.

5. Proteins: Structure and Significance

Proteins are polymers of **amino acids** linked by peptide bonds.

- **General Structure:** Contains an amino group (−NH2), a carboxyl group (−COOH), and a unique side chain (R).
- **Biological Significance: * Tissue Building:** Essential for growth and wound healing.
    - **Catalysis:** All enzymes are proteins.
    - **Fluid Balance:** Plasma proteins like Albumin maintain oncotic pressure.

6. Classification of Proteins

- **By Shape:** * *Fibrous:* Long, tough, insoluble (e.g., Collagen, Keratin).
    - *Globular:* Round, water-soluble (e.g., Hemoglobin, Albumin).
- **By Composition:** * *Simple:* Yield only amino acids (e.g., Albumin).
    - *Conjugated:* Protein plus a non-protein group (e.g., Glycoproteins, Hemoglobin).
- **By Function:** Enzymes, Hormones, Antibodies, and Transport proteins.
- **By Solubility:** Classified into Albumins (water-soluble) and Globulins (sparingly soluble).

7. Clinical Significance of Protein Denaturation

Denaturation is the loss of a protein's 3D structure due to heat, strong acids, or bases.

- **Clinical Link:** High-grade fever (>104°F) is dangerous because it can denature vital enzymes and brain proteins, leading to metabolic failure.
- **Sterilization:** Autoclaving kills bacteria by denaturing their essential proteins.

8. Food Sources of Nutrients

- **Carbohydrates:** Grains (rice, wheat), starchy vegetables (potatoes), fruits, and legumes.
- **Proteins:** Animal sources (meat, eggs, fish, milk) and plant sources (beans, nuts, soy).
- **Lipids:** Oils (olive, sunflower), butter, ghee, avocados, and nuts.

Name of the Nutrient	Sources	Function	
Carbohydrates (energy giving food)	Rice, potato, wheat, sugar	Provides energy	
Fats (energy giving food)	Butter, ghee, milk, cheese	Gives more energy compared to carbohydrates	
Vitamins and minerals (protective food)	Fruits and vegetables	Required for normal growth and development	
Proteins (body building food)	Milk, eggs, meat, fish, soybean	Helps in building and repair of body	

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Which nutrient is the primary fuel for the brain?	Protein	**Glucose**	Lipid	Fiber	**B**
2	Which bond links amino acids together?	Ionic	**Peptide**	Glycosidic	Hydrogen	**B**
3	A disaccharide found specifically in milk is:	Sucrose	Maltose	**Lactose**	Fructose	**C**
4	"Good Cholesterol" is clinically referred to as:	LDL	**HDL**	Triglyceride	VLDL	**B**
5	The storage form of glucose in humans is:	Starch	**Glycogen**	Cellulose	Insulin	**B**

6	Which protein maintains blood oncotic pressure?	Keratin	**Albumin**	Hemoglobin	Myosin	**B**
7	Which lipid forms the cell membrane bilayer?	Steroid	**Phospholipid**	Triglyceride	Wax	**B**
8	Cooking an egg is an example of:	Synthesis	**Denaturation**	Hydrolysis	Reduction	**B**
9	How much energy does 1 gram of fat provide?	4 kcal	7 kcal	**9 kcal**	12 kcal	**C**
10	Collagen (found in skin and bone) is a:	**Fibrous protein**	Globular protein	Carbohydrate	Enzyme	**A**
11	Sucrose is a disaccharide made of:	Glu + Gal	**Glu + Fru**	Glu + Glu	Fru + Gal	**B**
12	LDL transport cholesterol from:	Blood to Liver	**Liver to Blood**	Brain to Heart	Fat to Muscle	**B**
13	Which carbohydrate is indigestible by humans?	Starch	Glycogen	**Cellulose**	Amylose	**C**
14	Enzymes are biological catalysts made of:	Lipids	**Proteins**	Sugars	Minerals	**B**
15	Triglycerides are stored in:	Muscle tissue	**Adipose tissue**	Liver tissue	Bone marrow	**B**
16	Hemoglobin is classified as a:	Simple protein	**Conjugated protein**	Fibrous protein	Lipid	**B**
17	Which food is a "complete protein" source?	Bread	**Eggs**	Corn	Potato	**B**
18	Protein-sparing action means:	Eating no carbs	**Carbs prevent protein burning**	Protein prevents fat burning	Only eating protein	**B**
19	A pH change in blood can cause proteins to:	Multiply	**Denature**	Shrink	Dissolve	**B**
20	Steroid hormones are derived from:	**Cholesterol**	Glucose	Amino acids	Fatty acids	**A**

Unit III: Chemistry of Nutrients — Short Questions (SQs)

Q1: What is the "Protein Sparing Action" of carbohydrates?

Answer: If the body receives an adequate supply of carbohydrates, it uses them as the primary fuel source instead of burning protein for energy. This "spares" the protein, allowing it to be used for its essential functions like tissue repair, growth, and wound healing.

Q2: Differentiate between LDL and HDL from a clinical perspective.

Answer: LDL (Low-Density Lipoprotein) is known as "Bad Cholesterol" because it transports cholesterol from the liver to the arteries, potentially causing plaque buildup. **HDL (High-Density Lipoprotein)** is "Good Cholesterol" because it carries excess cholesterol away from the blood vessels and back to the liver for excretion. Nurses monitor these levels to assess cardiovascular risk.

Q3: Why is Protein Denaturation dangerous for a patient?

Answer: Denaturation destroys the specific 3D shape of a protein. If vital proteins like enzymes or hemoglobin lose their shape due to high-grade fever or extreme pH changes, they can no longer function. This can lead to metabolic failure or cellular death, making it a medical emergency.

Q4: Why are Phospholipids described as "Amphipathic"?

Answer: They are called amphipathic because they possess both a **hydrophilic** (water-attracted) head and a **hydrophobic** (water-repelling) tail. This unique property allows them to form the semi-permeable lipid bilayer of cell membranes.

Q5: State two differences between Monosaccharides and Polysaccharides. Answer: 1. **Complexity:**Monosaccharides are simple single-sugar units (e.g., Glucose), while Polysaccharides are complex long chains of sugar units (e.g., Glycogen). 2. **Function:** Monosaccharides provide immediate energy, whereas Polysaccharides serve as energy storage or structural support.

Q6: Distinguish between Fibrous and Globular proteins.

Answer: Fibrous proteins are long, thread-like, and insoluble in water; they provide structural support (e.g., Collagen in skin). **Globular proteins** are spherical, water-soluble, and involved in metabolic processes (e.g., Albumin and Hemoglobin).

Q7: What is the biological role of Glycogen?

Answer: Glycogen is the storage form of glucose in humans, primarily located in the liver and skeletal muscles. When blood glucose levels drop (e.g., during fasting), the body breaks down glycogen to release glucose back into the bloodstream for energy.

Q8: Define "Essential Amino Acids.

Answer: Essential amino acids are those that the human body cannot synthesize on its own at a rate sufficient for growth and repair. Therefore, they must be obtained through the diet (e.g., from meat, eggs, or legumes).

Q9: List two biological functions of Lipids.

Answer: 1. **Energy Storage:** They provide the most concentrated form of energy (9 kcal/g).
2. **Protection:** They provide a cushioning effect to protect vital internal organs like the kidneys and heart from mechanical shock.

Q10: Identify common food sources for Carbohydrates and Proteins.

Answer: * **Carbohydrates:** Rice, wheat (bread/roti), potatoes, and sugary fruits.

- **Proteins:** Chicken, fish, eggs, milk, lentils (pulses), and beans.

Unit IV: Nucleic Acid & Nucleotide

Unit Objectives:

1. Describe the main structural features of nucleotide.
2.Explain the structure of RNA and DNA and their differences.
3.Discuss the biological importance of nucleotides.

1. Structural Features of a Nucleotide

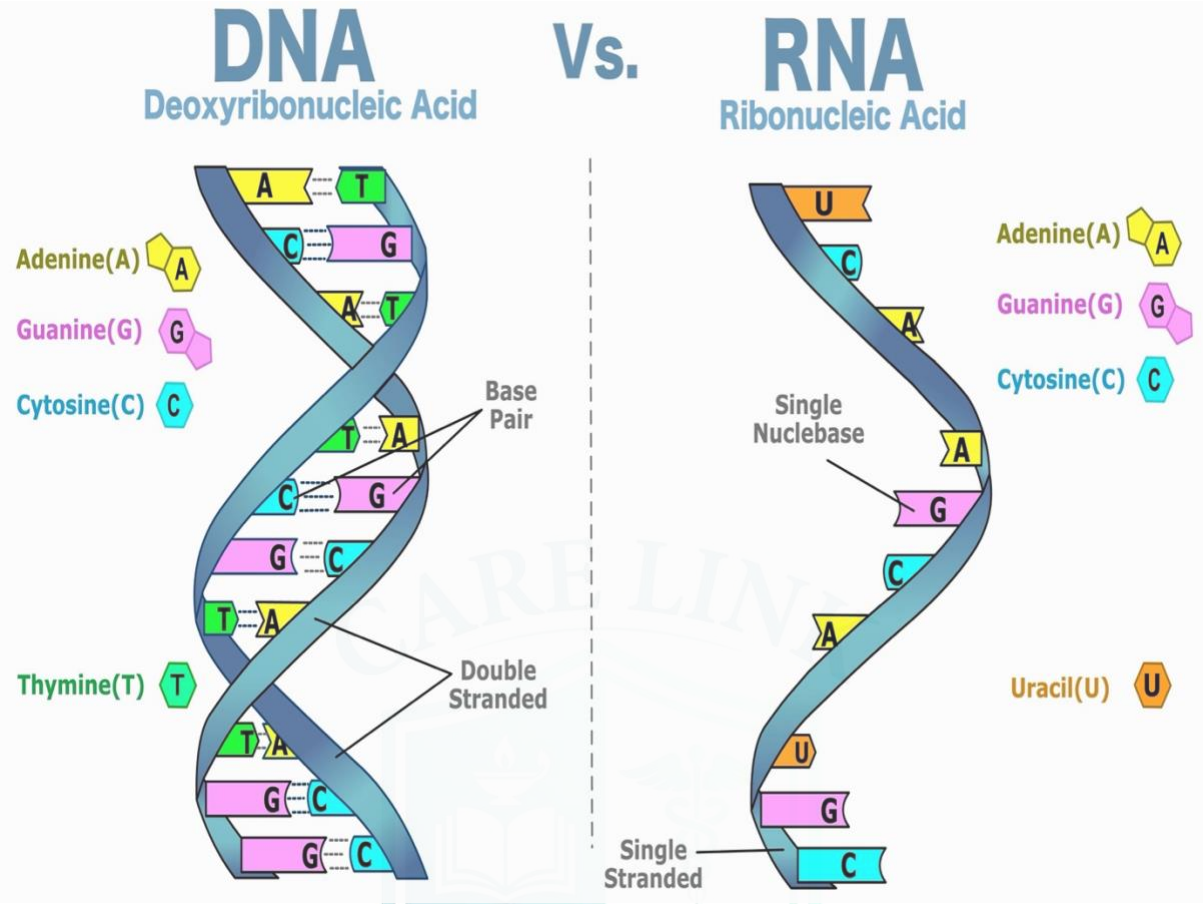
A **Nucleotide** is the basic building block (monomer) of nucleic acids. Every single nucleotide is composed of three distinct parts:

- **Pentose Sugar:** A 5-carbon sugar. It is either **Ribose** (in RNA) or **Deoxyribose** (in DNA).
- **Phosphate Group:** Attached to the sugar, this group gives DNA and RNA their acidic properties and forms the "backbone" of the chain.
- **Nitrogenous Base:** This is the variable part that carries the genetic code. Bases are divided into:
    - **Purines:** Adenine (A) and Guanine (G).
    - **Pyrimidines:** Cytosine (C), Thymine (T) — only in DNA, and Uracil (U) — only in RNA.

2. Structure of DNA and RNA (Differences)

While both carry genetic information, their structures and roles are very different.

Feature	DNA (Deoxyribonucleic Acid)	RNA (Ribonucleic Acid)
Structure	Double-stranded helix.	Usually single-stranded.
Sugar	Deoxyribose.	Ribose.
Bases	A, G, C, and **Thymine (T)**.	A, G, C, and **Uracil (U)**.
Location	Primarily in the Nucleus.	Nucleus, Cytoplasm, and Ribosomes.
Function	Permanent storage of genetic info.	Protein synthesis and gene regulation.



3. Biological Importance of Nucleotides

Nucleotides are not just for DNA; they have vital roles in clinical physiology:

- **Energy Currency: ATP** (Adenosine Triphosphate) is a nucleotide that provides the energy for every muscle contraction and nerve impulse you monitor in patients.
- **Genetic Blueprint:** DNA stores the instructions for every protein in the body.
- **Protein Synthesis:** RNA translates the DNA code into actual proteins (like hemoglobin or insulin).
- **Signal Transduction:** Nucleotides like cyclic AMP (cAMP) act as secondary messengers in hormone signaling.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Which sugar is found in DNA?	Ribose	**Deoxyribose**	Glucose	Fructose	**B**

2	The nitrogenous base found **only** i n RNA is:	Thymine	Adenine	**Uracil**	Cytosine	**C**
3	Which nucleotide is the main energy carrier in cells?	DNA	**ATP**	RNA	cGMP	**B**
4	How many strands are typically found in a DNA molecule?	One	**Two**	Three	Four	**B**
5	Adenine always pairs with which base in DNA?	Guanine	Cytosine	**Thymine**	Uracil	**C**
6	The "backbone" of a nucleic acid consists of:	Base + Sugar	**Sugar + Phosphate**	Base + Phosphate	Protein	**B**
7	Which of the following are categorized as Purines?	C and T	**A and G**	A and U	G and C	**B**
8	DNA is primarily located in which part of the cell?	Ribosome	Cytoplasm	**Nucleus**	Lysosome	**C**
9	The process of making RNA from DNA is called:	Translation	**Transcriptio n**	Replication	Denaturatio n	**B**
10	A nucleoside plus a phosphate group becomes a:	**Nucleotide**	Protein	Lipid	Carbohydrat e	**A**

11	Which bond holds the two strands of DNA together?	Ionic	Peptide	**Hydrogen**	Covalent	**C**
12	In RNA, Guanine (G) always pairs with:	Adenine	**Cytosine**	Thymine	Uracil	**B**
13	Thymine is replaced by which base in RNA?	Adenine	Guanine	Cytosine	**Uracil**	**D**
14	ATP stands for Adenosine _____:	Diphosphate	**Triphosphate**	Monophosphate	Tetrachloride	**B**
15	Which base is a Pyrimidine?	Adenine	Guanine	**Cytosine**	None	**C**
16	Genetic information is stored in the _____ of bases.	Color	Size	**Sequence**	Weight	**C**
17	RNA is essential for the synthesis of:	Lipids	**Proteins**	Sugars	Minerals	**B**
18	The sugar in RNA has how many Oxygen atoms more than DNA?	**One**	Two	Zero	Three	**A**
19	DNA stands for _____ Acid.	**Deoxyribonucleic**	Ribonucleic	Di-nucleic	Daily-nucleic	**A**
20	Cyclic AMP (cAMP) functions as a:	Energy source	**Second messenger**	Structural unit	Enzyme	**B**

Part 2: Short Questions (SQs)

Q1: List the three components of a nucleotide. Answer: Every nucleotide consists of a **Nitrogenous Base** (A, G, C, T, or U), a **Pentose Sugar** (Ribose or Deoxyribose), and a **Phosphate Group**.

Q2: Differentiate between the sugars found in DNA and RNA. Answer: DNA contains **Deoxyribose sugar**, which lacks one oxygen atom at the 2' carbon. RNA contains **Ribose sugar**, which has a hydroxyl (−OH) group at the 2' carbon.

Q3: What are the base-pairing rules for DNA? Answer: In DNA, Adenine (A) always pairs with Thymine (T) via two hydrogen bonds, and Guanine (G) always pairs with Cytosine (C) via three hydrogen bonds.

Q4: Why is ATP considered a biologically important nucleotide? Answer: ATP (Adenosine Triphosphate) is known as the "energy currency" of the cell. It stores and provides the necessary energy for vital biological processes like active transport and muscle contraction.

Q5: Describe the structural shape of DNA. Answer: DNA is structured as a **double helix**, resembling a twisted ladder.The two strands run in opposite directions (anti-parallel) and are held together by hydrogen bonds between the bases.

Q6: What is the main functional difference between DNA and RNA? Answer: DNA serves as the long-term storage of genetic information (the master blueprint), while RNA is responsible for carrying that information to ribosomes to synthesize proteins.

Q7: Define Purines and Pyrimidines with examples. Answer: Purines are double-ringed nitrogenous bases (Adenine and Guanine). **Pyrimidines** are single-ringed nitrogenous bases (Cytosine, Thymine, and Uracil).

Q8: What is a Nucleoside? Answer: A nucleoside is a molecule consisting of a nitrogenous base attached to a sugar, but **without** a phosphate group. Once a phosphate is added, it becomes a nucleotide.

Q9: Where is RNA typically found in the cell? Answer: RNA can be found in the **nucleus** (where it is made), the **cytoplasm**, and specifically on **ribosomes**, where it helps build proteins.

Q10: What is the clinical significance of understanding nucleic acids for nurses? Answer: Understanding nucleic acids is vital for understanding genetic disorders, the mechanism of viral infections, cancer treatments (chemotherapy often targets DNA replication), and modern diagnostics like PCR.

Unit V: Bioenergetics

Unit Objectives:

1. Define bioenergetics.
2. Discuss the biological oxidation and reduction reaction.
3. Describe the processes of energy transformations such as electron transport chain and oxidative phosphorylation.

1. Definition of Bioenergetics

Bioenergetics is the branch of biochemistry that focuses on how energy flows through living systems. It involves the study of energy transformations in cells and the nature of the chemical bonds that store and release this energy.

2. Biological Oxidation and Reduction

In the body, energy is moved by transferring electrons. These are called **Redox Reactions**.

- **Oxidation:** The loss of electrons or the removal of hydrogen.
- **Reduction:** The gain of electrons or the addition of hydrogen.
- **Biological Carriers:** Molecules like NAD+ and FAD act as "electron shuttles," picking up electrons from food (becoming reduced to NADH and FADH2) and carrying them to the energy-producing machinery of the cell.

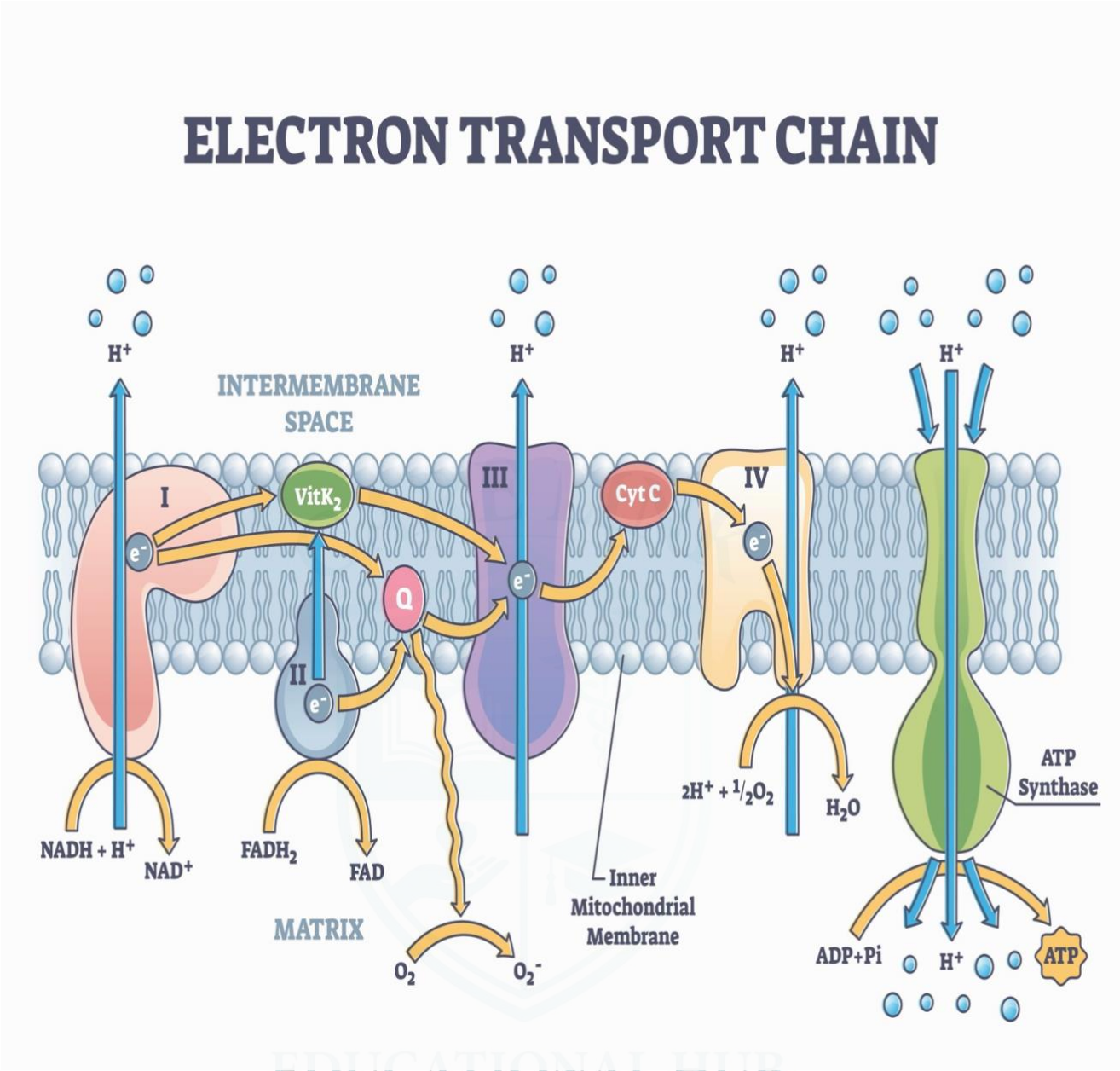
3. Energy Transformation Processes

The mitochondria is the "powerhouse" where two main processes occur to create ATP:

A. Electron Transport Chain (ETC)

The ETC consists of a series of protein complexes located in the inner mitochondrial membrane.

- Electrons from NADH and FADH2 are passed from one carrier to another.
- As electrons move, energy is released to pump hydrogen ions (H+) across the membrane, creating a gradient.
- **Oxygen** is the final electron acceptor, combining with H+ to form water (H2O). This is why we breathe.



B. Oxidative Phosphorylation

This is the process where ATP is actually synthesized.

- The H+ gradient created by the ETC flows back into the mitochondrial matrix through a special enzyme called **ATP Synthase**.
- This flow of ions acts like water turning a turbine, providing the energy to attach a phosphate to ADP, creating **ATP**.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Bioenergetics is the study of _____ in living systems.	Fluid flow	**Energy flow**	Blood flow	Air flow	**B**
2	In biological systems, **Oxidation** is defined as the:	Gain of electrons	**Loss of electrons**	Gain of water	Loss of oxygen	**B**
3	The primary site of ATP production in the cell is:	Ribosome	Nucleus	**Mitochondria**	Golgi body	**C**
4	Which molecule is known as the "Energy Currency"?	Glucose	DNA	**ATP**	RNA	**C**
5	The final electron acceptor in the Electron Transport Chain is:	Nitrogen	Carbon	**Oxygen**	Hydrogen	**C**
6	When NAD+ becomes NADH, it has been:	Oxidized	**Reduced**	Denatured	Hydrolyzed	**B**
7	ATP stands for Adenosine _____:	Diphosphate	**Triphosphate**	Monophosphate	Tri-acid	**B**
8	The enzyme that produces ATP from the H+ gradient is:	Amylase	Lipase	**ATP Synthase**	Helicase	**C**
9	Oxidative Phosphorylation occurs in the:	**Mitochondria**	Cytoplasm	Lysosome	ER	**A**
10	The movement of electrons in the ETC creates a/an:	Oxygen gap	**Proton gradient**	Protein chain	Sugar bond	**B**
11	Which of the following is a reduced electron carrier?	NAD+	FAD	**NADH**	ADP	**C**
12	Energy transformation in the body is 100% efficient.	True	**False**	Only in sleep	Only in heat	**B**
13	Red-Ox stands for:	Reduction-Oxygen	**Reduction-Oxidation**	Real-Oxidation	Red-Oxygen	**B**
14	How many phosphates are in one molecule of ATP?	One	Two	**Three**	Four	**C**
15	The ETC is located in the _____ mitochondrial membrane.	Outer	**Inner**	Middle	Nuclear	**B**
16	If oxygen is unavailable, the ETC will:	Speed up	**Stop**	Stay the same	Change to DNA	**B**

17	Adding a phosphate group to a molecule is called:	Oxidation	Reduction	**Phosphorylation**	Hydration	**C**
18	Bioenergetics follows the laws of:	Biology	**Thermodynamics**	Chemistry	Nursing	**B**
19	FADH2 and NADH are produced during:	**Metabolism**	Filtration	Circulation	Respiration	**A**
20	What is the byproduct of the ETC?	Glucose	**Water**	Carbon	Urea	**B**

Part 2: Short Questions (SQs)

Q1: Define Bioenergetics. Answer: Bioenergetics is the study of how energy is captured, transformed, and utilized by living organisms to perform biological work and maintain life.

Q2: What is the difference between Oxidation and Reduction? Answer: Oxidation is the loss of electrons or hydrogen atoms from a molecule, while Reduction is the gain of electrons or hydrogen atoms. In biological systems, these two always occur together as "Redox" reactions.

Q3: Explain the role of ATP in the body. Answer: ATP (Adenosine Triphosphate) acts as the chemical "energy currency." It stores energy in high-energy phosphate bonds and releases it when needed for muscle contraction, active transport, and chemical synthesis.

Q4: What is the primary function of the Electron Transport Chain (ETC)? Answer: The primary function of the ETC is to use energy from electrons (carried by NADH and FADH2) to pump protons (H+) across the inner mitochondrial membrane, creating a proton gradient.

Q5: Briefly describe Oxidative Phosphorylation. Answer: It is the process where ATP is synthesized as a result of electron transport. It uses the energy from the proton gradient to drive the enzyme **ATP Synthase**, which converts ADPand inorganic phosphate into ATP.

Q6: Why is Oxygen vital for the process of Bioenergetics? Answer: Oxygen serves as the final electron acceptor at the end of the Electron Transport Chain. Without oxygen, the chain stops, ATP production ceases, and the cell can die.

Q7: What are NADH and FADH2? Answer: These are reduced coenzymes that act as electron carriers. They collect electrons from metabolic pathways (like the Krebs cycle) and deliver them to the Electron Transport Chain.

Q8: What is the "Proton Gradient"? Answer: It is a difference in the concentration of hydrogen ions (H+) across a membrane. In mitochondria, this gradient represents a form of stored potential energy used to make ATP.

Q9: Where exactly do ETC and Oxidative Phosphorylation take place? Answer: Both processes occur within the **mitochondria**, specifically on and across the **inner mitochondrial membrane** (cristae).

Q10: What is the clinical significance of Bioenergetics for a nurse? Answer: Understanding bioenergetics helps nurses understand the effects of hypoxia (low oxygen), metabolic disorders, and why patients with high metabolic demands (like fever or trauma) need adequate nutrition and oxygenation.

Unit VI: Enzymology

Unit Objectives:

1. Discuss the important classification of enzymes and their clinical significance.
2. Distinguish between Apo enzymes, coenzymes & co factors.
3. Distinguish between activators and inhibitors.
4. Understand inhibition of enzyme activity in competitive and noncompetitive inhibitors.
5. Explain the mode of enzyme activity and factors affecting it.
6. Identify enzymes that help in food metabolism.

1. Classification and Clinical Significance

Enzymes are generally classified into six major groups based on the type of reaction they catalyze:

1. **Oxidoreductases:** Catalyze redox reactions.
2. **Transferases:** Transfer functional groups (e.g., Kinases).
3. **Hydrolases:** Break bonds using water (e.g., Digestive enzymes).
4. **Lyases:** Break bonds without water.
5. **Isomerases:** Rearrange atoms within a molecule.
6. **Ligases:** Join two molecules together.

Clinical Significance: When organs are damaged, enzymes leak into the blood.

- **Troponin/CK-MB:** Elevated in Myocardial Infarction (Heart Attack).
- **ALT/AST:** Indicators of Liver damage.
- **Amylase/Lipase:** Indicators of Pancreatitis.

2. Enzyme Components: Apoenzymes, Coenzymes & Cofactors

Many enzymes require a non-protein helper to function.

- **Apoenzyme:** The protein part of the enzyme (inactive by itself).
- **Cofactor:** An inorganic ion (e.g., Mg^{2+}, Fe^{2+}, Zn^{2+}).
- **Coenzyme:** An organic molecule, often derived from vitamins (e.g., NAD, FAD).
- **Holoenzyme:** The complete, active enzyme (**Apoenzyme + Cofactor/Coenzyme**).

3. Activators vs. Inhibitors

- **Activators:** Molecules that increase enzyme activity (e.g., certain metal ions).
- **Inhibitors:** Molecules that decrease or stop enzyme activity.

4. Competitive vs. Non-competitive Inhibition

Inhibition is how many drugs (like ACE inhibitors for BP) work.

- **Competitive:** The inhibitor resembles the substrate and competes for the **Active Site**. It can be overcome by adding more substrate.
- **Non-competitive:** The inhibitor binds to a different site (**Allosteric Site**). This changes the enzyme's shape so the substrate no longer fits. It cannot be overcome by more substrate.

[Image comparing competitive and non-competitive enzyme inhibition mechanisms]

5. Mode of Action and Factors Affecting Activity

Enzymes work by lowering the **Activation Energy** of a reaction.

- **Lock and Key Model:** The enzyme's active site is a perfect fit for the substrate.
- **Induced Fit Model:** The enzyme slightly changes shape to "hug" the substrate.

Factors Affecting Activity:

1. **Temperature:** Most human enzymes work best at 37°C. High fever denatures them.
2. **pH:** Most work at neutral pH, but stomach enzymes (Pepsin) require acidic pH (2.0).
3. **Concentration:** Increasing substrate or enzyme concentration increases the rate (until a saturation point).

6. Enzymes in Food Metabolism

- **Carbohydrates:** Salivary/Pancreatic **Amylase** breaks starch into sugars.
- **Proteins: Pepsin** (stomach) and **Trypsin** (small intestine) break proteins into amino acids.
- **Lipids: Lipase** breaks fats into fatty acids and glycerol.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Enzymes are chemically made of:	Lipids	**Proteins**	Sugars	Minerals	**B**
2	The protein part of an enzyme is called:	Holoenzyme	**Apoenzyme**	Coenzyme	Cofactor	**B**
3	Which enzyme is a marker for liver damage?	Troponin	**ALT**	Amylase	Pepsin	**B**
4	Competitive inhibitors bind to the:	Allosteric site	**Active site**	Surface	Product	**B**
5	Enzymes speed up reactions by lowering:	Temperature	pH	**Activation Energy**	Pressure	**C**

Sr. No	Question	Option A	Option B	Option C	Option D	
6	Inorganic ions like Zn2+ that help enzymes are:	Coenzymes	**Cofactors**	Apoenzymes	Isomers	**B**
7	Salivary Amylase helps in the digestion of:	Proteins	Fats	**Carbohydrates**	DNA	**C**
8	At very high temperatures, enzymes become:	More active	Smaller	**Denatured**	Inorganic	**C**
9	Pepsin works best at which pH?	7.0 (Neutral)	10.0 (Basic)	**2.0 (Acidic)**	14.0	**C**
10	Non-competitive inhibitors bind to the:	Active site	**Allosteric site**	Substrate	Water	**B**
11	An active enzyme (protein + helper) is a:	**Holoenzyme**	Coenzyme	Proenzyme	Lyase	**A**
12	Kinases belong to which class of enzymes?	Hydrolases	**Transferases**	Ligases	Isomerases	**B**
13	Which enzyme is used to diagnose a Heart Attack?	Lipase	**CK-MB**	Amylase	Sucrase	**B**
14	Substrate binds to which part of the enzyme?	**Active Site**	Tail	Backbone	Nucleus	**A**
15	Coenzymes are often derived from:	Minerals	**Vitamins**	Fats	Sugars	**B**
16	Enzyme activity _____ as temperature rises to 37°C.	Decreases	**Increases**	Stops	Fluctuates	**B**
17	Trypsin is an enzyme that digests:	Fats	Sugars	**Proteins**	Starch	**C**
18	The "Lock and Key" model explains enzyme:	**Specificity**	Weight	Color	Size	**A**
19	Ligases are enzymes that:	Break bonds	**Join molecules**	Transfer groups	Reduce atoms	**B**
20	Lipase is primarily produced by the:	Saliva	Stomach	**Pancreas**	Liver	**C**

Part 2: Short Questions (SQs)

Q1: Define Enzymes and their primary function. Answer: Enzymes are biological catalysts, mostly protein in nature.Their primary function is to speed up chemical reactions in the body by lowering the activation energy required for the reaction to start.

Q2: Differentiate between a Cofactor and a Coenzyme. Answer: Both are non-protein helpers. A **Cofactor** is usually an inorganic metal ion (like Mg2+ or Fe2+), whereas a **Coenzyme** is a small organic molecule, often derived from vitamins (like NAD or FAD).

Q3: Explain the "Lock and Key" hypothesis. Answer: This model suggests that the enzyme's active site has a specific geometric shape that matches the substrate exactly, like a key fits into a specific lock. This explains why enzymes are highly specific to their substrates.

Q4: What is the clinical significance of measuring serum enzymes? Answer: Enzymes are usually contained within cells. Their presence in high amounts in the blood (serum) indicates tissue or organ damage. For example, high Troponin levels indicate heart muscle damage (Myocardial Infarction).

Q5: How does a Competitive Inhibitor work? Answer: A competitive inhibitor has a structure similar to the substrate. it competes for the active site of the enzyme, blocking the actual substrate from binding. This inhibition can be reversed by increasing the substrate concentration.

Q6: What is an Allosteric Site? Answer: An allosteric site is a location on the enzyme other than the active site. Non-competitive inhibitors bind here, causing the enzyme to change shape, which prevents the substrate from fitting into the active site.

Q7: Why does a very high fever (Hyperpyrexia) affect enzyme activity? Answer: Enzymes are proteins, and their shape is held by weak bonds. High heat provides enough energy to break these bonds, causing the enzyme to unfold and lose its shape (**Denaturation**), making it non-functional.

Q8: Name the enzymes involved in the digestion of a piece of bread (starch). Answer: The digestion of starch begins in the mouth with **Salivary Amylase** and continues in the small intestine with **Pancreatic Amylase**, which breaks it down into maltose and eventually glucose.

Q9: Distinguish between Apoenzyme and Holoenzyme. Answer: An **Apoenzyme** is the inactive protein part of an enzyme that requires a cofactor. A **Holoenzyme** is the complete, biochemically active enzyme consisting of the apoenzyme plus its cofactor or coenzyme.

Unit VII: Metabolism

Unit Objectives:

1. Define metabolism and its types; anabolism and catabolism.
2. Discuss the process of energy derivation from organic compounds.
3. Define the terms, gluconeogenesis, glycogenesis, glycogenolysis, transamination, deamination, and ketosis.

1. Definition and Types of Metabolism

Metabolism is the process by which the body converts what you eat and drink into energy. It is divided into two contrasting pathways:

- **Anabolism (Building Up):** The process of synthesizing complex molecules from simpler ones. This requires energy (ATP). Examples include protein synthesis for muscle repair and **Glycogenesis** (storing sugar).
- **Catabolism (Breaking Down):** The process of breaking down complex molecules into simpler units to release energy (ATP). Examples include digestion and **Glycolysis** (burning sugar).

2. Energy Derivation from Organic Compounds

The body derives energy from three main organic sources: Carbohydrates, Lipids, and Proteins.

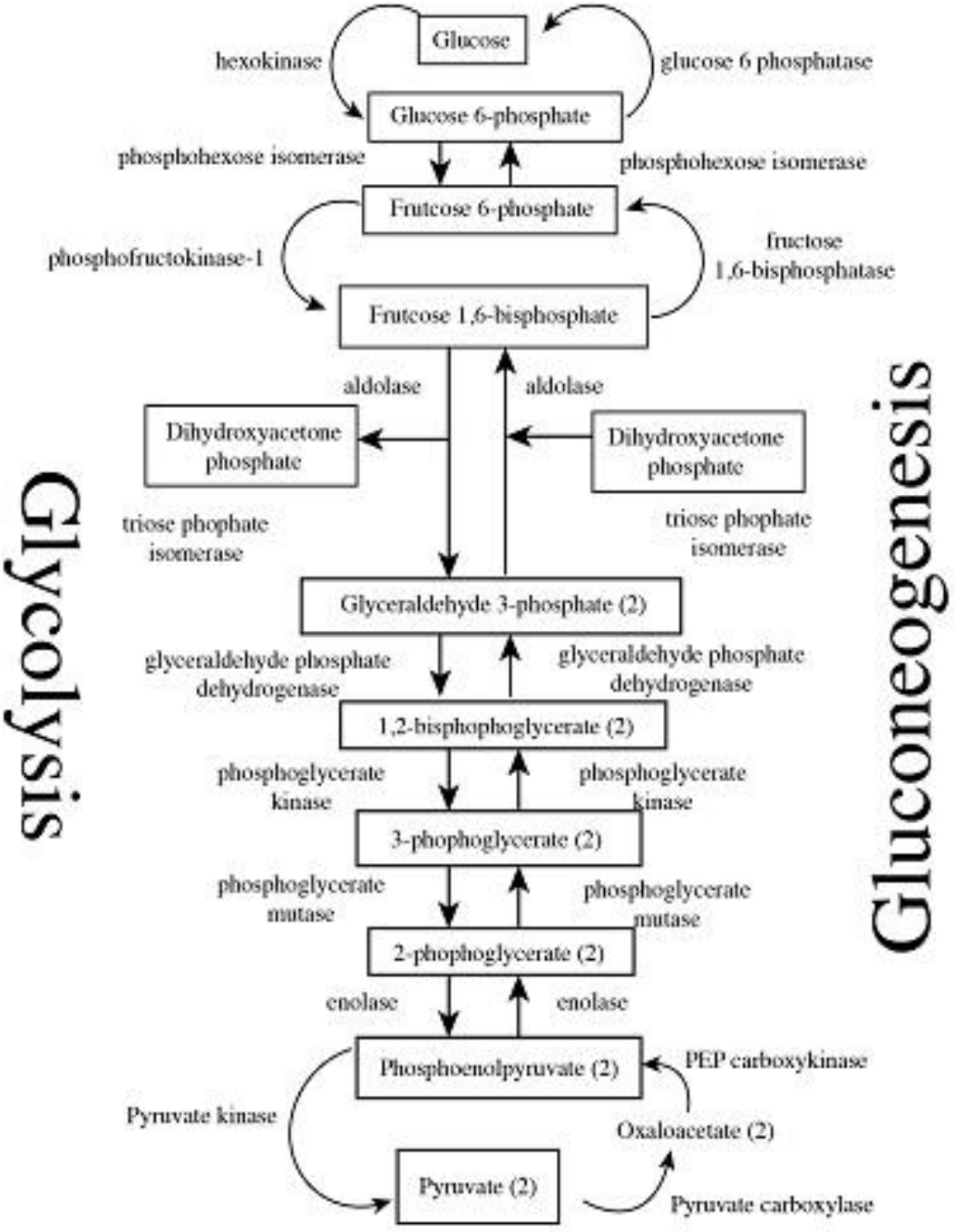
1. **Carbohydrates:** The primary and fastest source of energy. They are broken down into **Glucose**, which enters Glycolysis and the Krebs cycle to produce ATP.
2. **Lipids (Fats):** The most concentrated energy source. Fats are broken down via **Beta-oxidation** into Acetyl-CoA to enter the energy cycle.
3. **Proteins:** Used as a last resort for energy (e.g., during starvation). Proteins are broken down into amino acids, which must lose their nitrogen group (Deamination) before entering energy pathways.

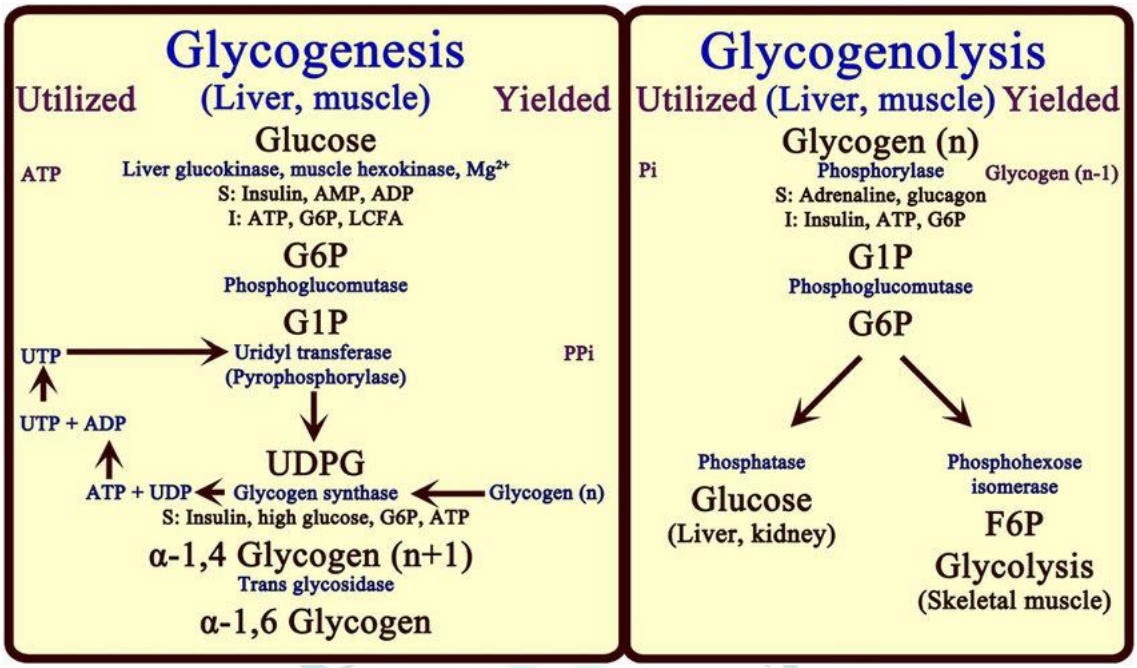
3. Key Metabolic Terms

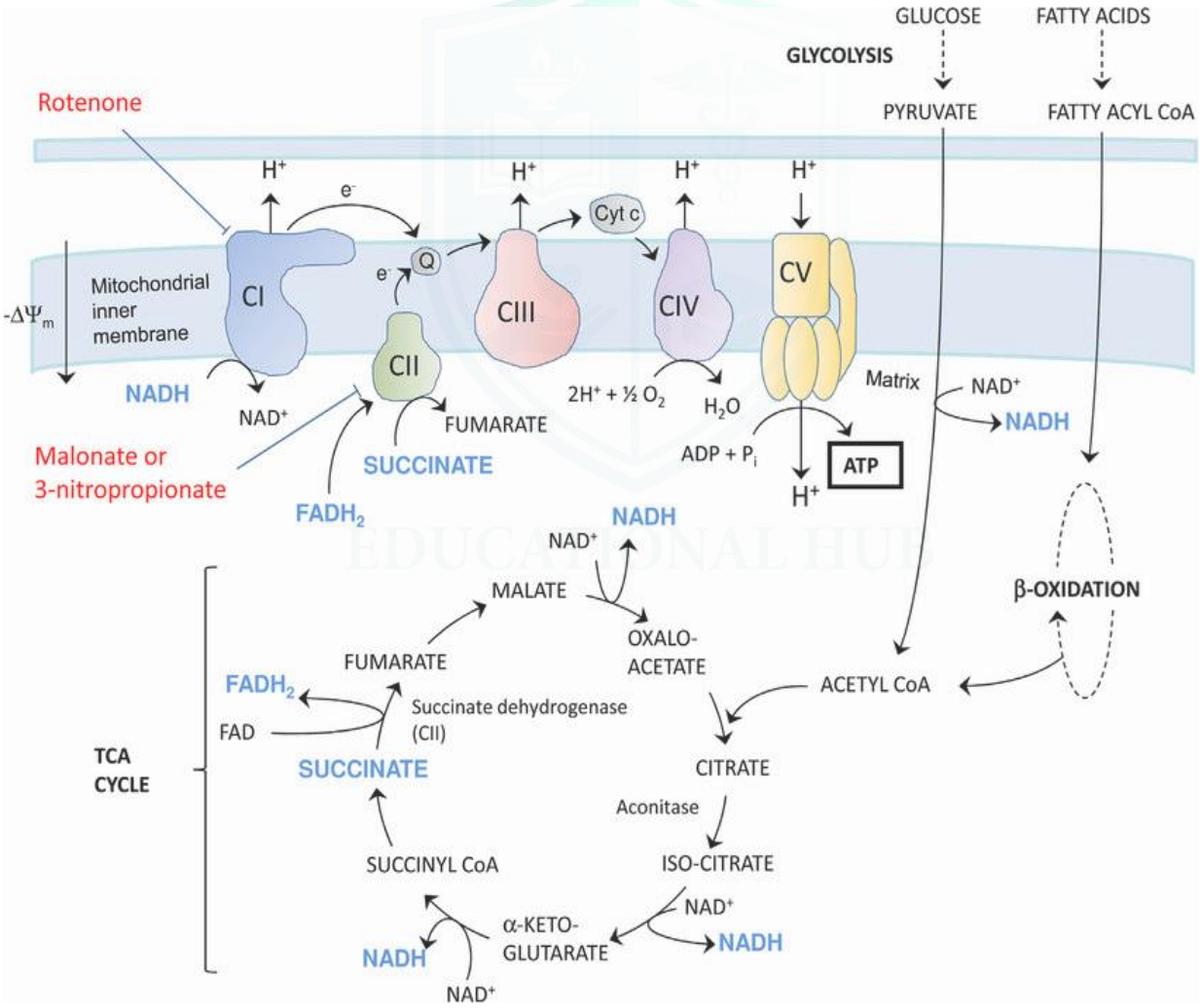
In clinical practice, especially when managing diabetic patients or those in ICU, these terms are vital:

- **Glycogenesis:** The process of converting excess glucose into **Glycogen** for storage in the liver and muscles.(Occurs after a meal).
- **Glycogenolysis:** The breakdown of stored glycogen back into glucose. (Occurs during fasting or exercise to maintain blood sugar).
- **Gluconeogenesis:** The formation of "new" glucose from **non-carbohydrate** sources like amino acids or glycerol.(Occurs during prolonged starvation).
- **Transamination:** The transfer of an amino group from one amino acid to a keto acid to create a new amino acid.

- **Deamination:** The **removal** of an amino group from an amino acid. The removed nitrogen is converted into **Urea**and excreted by the kidneys.
- **Ketosis:** A metabolic state where the body burns fat for fuel instead of carbs, producing **Ketone bodies**. If excessive (as in Type 1 Diabetes), it leads to life-threatening **Ketoacidosis**.




Glycogenesis
Utilized
(Liver, muscle)
Yielded
Glucose
ATP
Liver glucokinase, muscle hexokinase, Mg2+
S: Insulin, AMP, ADP
I: ATP, G6P, LCFA
G6P
Phosphoglucomutase
G1P
UTP
Uridyl transferase
(Pyrophosphorylase)
PPi
UTP + ADP
UDPG
ATP + UDP
Glycogen synthase
Glycogen (n)
S: Insulin, high glucose, G6P, ATP
α-1,4 Glycogen (n+1)
Trans glycosidase
α-1,6 Glycogen
Glycogenolysis
Utilized (Liver, muscle) Yielded
Glycogen (n)
Pi
Phosphorylase
Glycogen (n-1)
S: Adrenaline, glucagon
I: Insulin, ATP, G6P
G1P
Phosphoglucomutase
G6P
Phosphatase
Glucose
(Liver, kidney)
Phosphohexose
isomerase
F6P
Glycolysis
(Skeletal muscle)


GLUCOSE
FATTY ACIDS
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PYRUVATE
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Rotenone
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membrane
-ΔΨm
CI
CII
CIII
CIV
CV
NADH
NAD+
FUMARATE
2H+ + ½ O2
H2O
ADP + Pi
ATP
Matrix
Malonate or
3-nitropropionate
SUCCINATE
FADH2
β-OXIDATION
MALATE
OXALO-
ACETATE
FUMARATE
ACETYL CoA
Succinate dehydrogenase
(CII)
FAD
TCA
CYCLE
CITRATE
Aconitase
SUCCINYL CoA
ISO-CITRATE
α-KETO-
GLUTARATE

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	Correct Answer
1	The process of building complex molecules is:	Catabolism	**Anabolism**	Glycolysis	Deamination	**B**
2	Breaking down glycogen into glucose is called:	Glycogenesis	Gluconeogenesis	**Glycogenolysis**	Ketosis	**C**
3	Creating glucose from non-carb sources is:	Glycogenesis	**Gluconeogenesis**	Glycolysis	Lipolysis	**B**
4	The byproduct of deamination excreted by kidneys is:	Glucose	**Urea**	Ketones	Oxygen	**B**
5	Ketosis occurs when the body primarily burns:	Proteins	Carbohydrates	**Fats**	Minerals	**C**
6	Storing excess glucose as glycogen is:	**Glycogenesis**	Glycolysis	Lipogenesis	Deamination	**A**
7	Which process involves the removal of an amino group?	Transamination	**Deamination**	Glycogenesis	Ketosis	**B**
8	Catabolism results in the _____ of energy.	Storage	**Release**	Destruction	Synthesis	**B**
9	Glycogen is primarily stored in the:	Brain	**Liver & Muscles**	Bones	Kidneys	**B**
10	Amino acid nitrogen is	Kidneys	**Liver**	Heart	Lungs	**B**

Sr. No	Question	Option A	Option B	Option C	Option D	Correct Answer
	converted to urea in the:					
11	Anabolism is a/an _____ process.	**Energy-requiring**	Energy-releasing	Passive	Inorganic	**A**
12	Excessive ketone production can lead to:	Alkalosis	**Acidosis**	Cyanosis	Hypoxia	**B**
13	The "Master Molecule" that enters the Krebs cycle is:	Glucose	**Acetyl-CoA**	Urea	Lactate	**B**
14	During a 24-hour fast, the body first performs:	**Glycogenolysis**	Ketosis	Photosynthesis	Deamination	**A**
15	Transferring an amino group to another molecule is:	**Transamination**	Deamination	Digestion	Oxidation	**A**
16	Metabolism = Anabolism + _____:	Digestion	**Catabolism**	Respiration	Excretion	**B**
17	Insulin promotes which of the following?	Glycogenolysis	**Glycogenesis**	Gluconeogenesis	Ketosis	**B**
18	Glucagon promotes which of the following?	**Glycogenolysis**	Lipogenesis	Protein synthesis	Glycogenesis	**A**
19	Which nutrient is the "last resort" for energy?	Fats	**Proteins**	Carbohydrates	Vitamins	**B**
20	In which state is Glycogenesi	Fasting	**Post-prandial (After meal)**	Exercise	Sleep	**B**

Sr. No	Question	Option A	Option B	Option C	Option D	Correct Answer
	s most active?					

Part 2: Short Questions (SQs)

Q1: Define Metabolism and its two main types. Answer: Metabolism is the total sum of all chemical reactions in the body. Its two types are **Anabolism** (using energy to build complex molecules like proteins) and **Catabolism** (breaking down molecules like glucose to release energy).

Q2: What is the difference between Glycogenesis and Glycogenolysis? Answer: Glycogenesis is the creation of glycogen from glucose for storage (after eating). **Glycogenolysis** is the breakdown of that stored glycogen back into glucose for energy (during fasting).

Q3: Explain Gluconeogenesis. Answer: Gluconeogenesis is the metabolic pathway that results in the generation of glucose from non-carbohydrate carbon substrates such as lactate, glycerol, and glucogenic amino acids. It ensures the brain has glucose during starvation.

Q4: Why does the body perform Deamination? Answer: When the body needs to use amino acids for energy, it must first remove the nitrogen-containing amino group. This process is deamination. The nitrogen is toxic, so the liver converts it to urea for safe excretion.

Q5: What is Ketosis and when does it occur? Answer: Ketosis is a state where the body uses fats as its primary fuel source, producing ketone bodies. It occurs during starvation, very low-carb diets, or uncontrolled diabetes.

Q6: Briefly describe how energy is derived from Lipids. Answer: Lipids (triglycerides) are broken down into glycerol and fatty acids. Fatty acids undergo **Beta-oxidation** to produce Acetyl-CoA, which enters the mitochondria to produce a large amount of ATP.

Q7: Distinguish between Transamination and Deamination. Answer: Transamination is the *transfer* of an amino group from one molecule to another to make new amino acids. **Deamination** is the *removal* of the amino group entirely to use the carbon skeleton for energy.

Q8: What is the clinical importance of Glycogenolysis in a fasting patient? Answer: In a fasting patient, glycogenolysis prevents hypoglycemia (low blood sugar) by releasing glucose from the liver into the blood to fuel the brain and heart.

Q9: Where do Urea cycle and Gluconeogenesis primarily occur? Answer: Both of these critical metabolic processes occur primarily in the **Liver**.

Q10: Why is Ketoacidosis a medical emergency in diabetic patients? Answer: Because ketones are acidic. If they build up excessively, they lower the blood pH below 7.35,

disrupting enzyme function and leading to coma or death if not treated with insulin and fluids.

Unit VIII: Metabolism of Carbohydrates

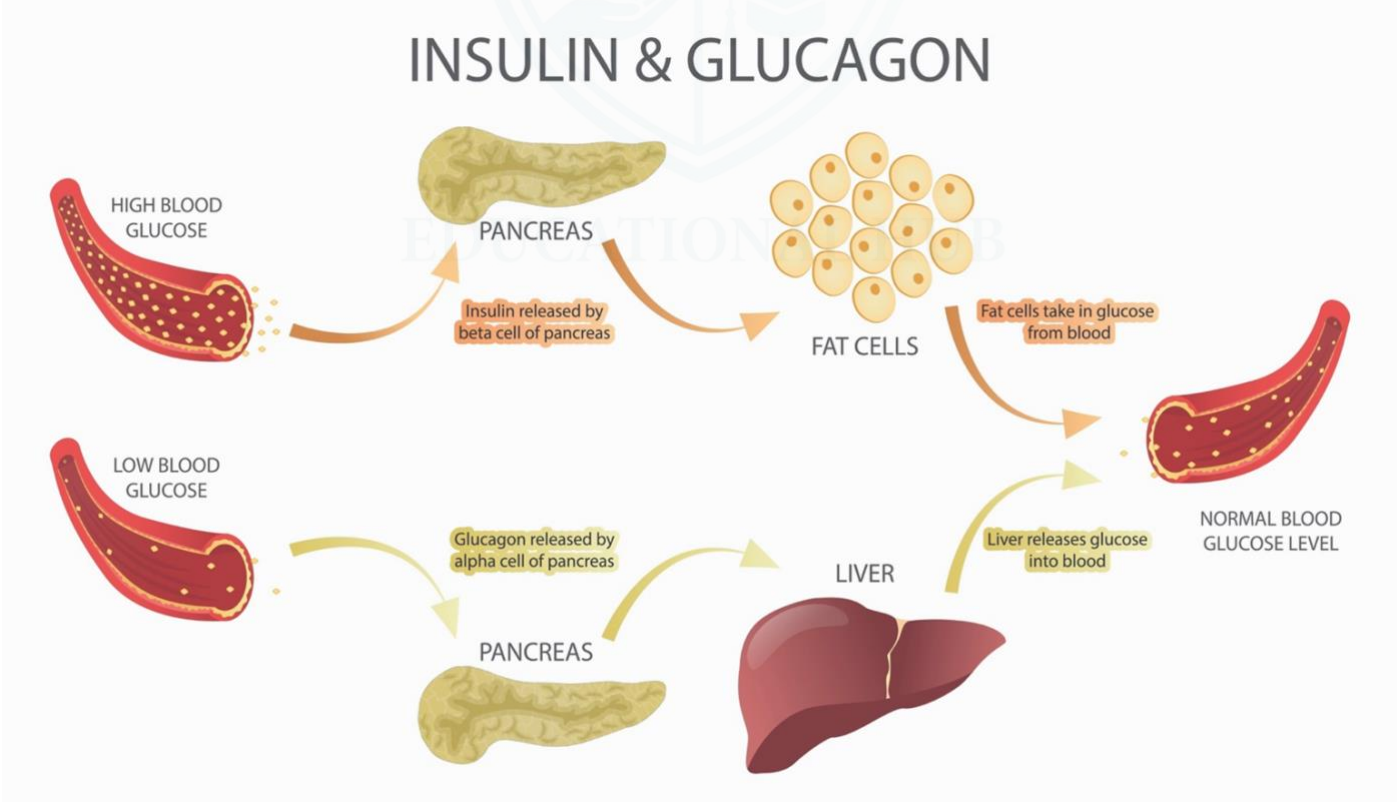
Unit Objectives:

1. Discuss the importance of glucose in blood and its dependency by various factors.
2. Discuss the metabolic pathways of carbohydrates such as glycogenesis and glycogenolysis.
3. Describe the role of oxidative glucose catabolism in the citric acid cycle.
4. Describe the role of gluconeogenesis.

1. Glucose in Blood: Importance and Regulation

Glucose is the essential "energy currency" for the body, particularly for the **Brain** and **Red Blood Cells**, which cannot use fats for energy.

- **Normal Range:** Blood glucose is strictly maintained between **70–110 mg/dL** (fasting).
- **Hormonal Regulation:**
  - **Insulin:** Lowers blood sugar by pushing glucose into cells.
  - **Glucagon:** Raises blood sugar by stimulating the liver to release stored glucose.
  - **Cortisol & Adrenaline:** Raise blood sugar during stress (the "Fight or Flight" response).
- **Dependency Factors:** Blood glucose levels depend on dietary intake, the rate of digestion, physical activity, and the functional health of the liver and pancreas.



2. Glycogenesis and Glycogenolysis

These are the "storage" and "retrieval" pathways for carbohydrates.

- **Glycogenesis (Storage):** The process of converting excess glucose into **Glycogen**. This occurs primarily in the **Liver** and **Skeletal Muscles** after a meal.
- **Glycogenolysis (Retrieval):** The breakdown of glycogen back into glucose-6-phosphate or free glucose. This happens during fasting or exercise when the body needs an immediate energy boost.

3. Oxidative Glucose Catabolism: The Citric Acid Cycle (Krebs Cycle)

Once glucose is broken down into **Pyruvate** (via Glycolysis) and converted into **Acetyl-CoA**, it enters the Citric Acid Cycle in the mitochondria.

- **Role:** The cycle "strips" electrons and protons from the carbon skeleton of the glucose derivative.
- **Products:** It produces a small amount of ATP, but its main job is to create **NADH** and **$FADH_2$**, which carry high-energy electrons to the Electron Transport Chain (ETC) to produce the bulk of the body's ATP.
- **Byproducts:** It releases **Carbon Dioxide (CO2)**, which we exhale.

4. The Role of Gluconeogenesis

Gluconeogenesis is the synthesis of glucose from **non-carbohydrate** sources (like amino acids, lactate, and glycerol).

- **When it happens:** During prolonged fasting (over 24 hours), starvation, or intense exercise.
- **Why it is vital:** It ensures that blood glucose levels do not drop to dangerous levels (hypoglycemia) once glycogen stores are exhausted, protecting brain function.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Which organ is almost entirely dependent on glucose for energy?	Heart	**Brain**	Liver	Lungs	**B**

Sr. No	Question	Option A	Option B	Option C	Option D	
2	Which hormone is the primary "hypoglycemic" agent (lowers sugar)?	Glucagon	**Insulin**	Cortisol	Thyroxine	**B**
3	Glycogenesis is most active during which state?	Fasting	Exercise	**After a meal**	Sleep	**C**
4	The breakdown of glycogen to glucose is called:	Glycolysis	**Glycogenolysis**	Gluconeogenesis	Lipolysis	**B**
5	The Citric Acid Cycle occurs in which part of the cell?	Cytoplasm	Nucleus	**Mitochondria**	Ribosome	**C**
6	Which molecule enters the Citric Acid Cycle?	Glucose	Pyruvate	**Acetyl-CoA**	Lactate	**C**
7	Gluconeogenesis primarily takes place in the:	**Liver**	Brain	Muscles	Pancreas	**A**
8	What is the main waste product of the Citric Acid Cycle?	Oxygen	**Carbon Dioxide**	Urea	Lactic Acid	**B**
9	A fasting blood sugar of 180 mg/dL indicates:	Hypoglycemia	Normal range	**Hyperglycemia**	Starvation	**C**
10	Which of these is a non-carb source for gluconeogenesis?	Starch	**Amino Acids**	Glycogen	Sucrose	**B**
11	The Citric Acid Cycle is also known as the:	Calvin Cycle	**Krebs Cycle**	Urea Cycle	Nitrogen Cycle	**B**
12	Glucagon stimulates which process in the liver?	Glycogenesis	Lipogenesis	**Glycogenolysis**	Protein synthesis	**C**
13	During "Fight or Flight," which hormone raises glucose?	Insulin	**Adrenaline**	Melatonin	Oxytocin	**B**
14	Glycogen is stored in the liver and _____:	**Muscles**	Adipose tissue	Brain	Kidneys	**A**
15	How many ATP are directly produced	10	32	**1 (as GTP)**	0	**C**

Sr. No	Question	Option A	Option B	Option C	Option D	
	per turn of the Citric Acid Cycle?					
16	The conversion of glucose to pyruvate is:	**Glycolysis**	Glycogenesis	Gluconeogenesis	Ketosis	**A**
17	Which vitamin derivative is a coenzyme in the Krebs cycle?	Vitamin C	Vitamin D	**B-Vitamins (NAD/FAD)**	Vitamin K	**C**
18	Gluconeogenesis becomes essential after how many hours of fasting?	1 hour	2 hours	**>24 hours**	5 minutes	**C**
19	High levels of insulin will inhibit:	Glycolysis	**Gluconeogenesis**	Protein synthesis	Glycogenesis	**B**
20	The net yield of energy is highest when glucose is:	Fermented	**Completely oxidized**	Stored as fat	Excreted	**B**

Part 2: Short Questions (SQs)

Q1: Why is maintaining blood glucose levels critical for a patient's survival? Answer: Glucose is the primary fuel for the Central Nervous System (CNS) and Red Blood Cells. Unlike other tissues, the brain cannot store glucose or efficiently use fats; therefore, a drop in blood sugar (hypoglycemia) can lead to immediate confusion, loss of consciousness, and brain death.

Q2: Differentiate between Glycogenesis and Glycogenolysis. Answer: Glycogenesis is the anabolic process of building glycogen from glucose for storage, triggered by high insulin after eating. **Glycogenolysis** is the catabolic process of breaking down glycogen into glucose to maintain blood sugar during fasting or activity, triggered by glucagon.

Q3: Describe the main purpose of the Citric Acid Cycle (Krebs Cycle). Answer: The primary purpose is to oxidize Acetyl-CoA to produce high-energy electron carriers (NADH and FADH2). These carriers then move to the Electron Transport Chain to generate the majority of the cell's ATP through oxidative phosphorylation.

Q4: Under what clinical conditions does Gluconeogenesis become active? Answer: It becomes active during prolonged fasting, starvation, or very low-carbohydrate diets. Clinically, it is also seen in uncontrolled Diabetes Mellitus and during severe metabolic stress or trauma where the body's glucose demand exceeds its stores.

Q5: What are the primary "starting materials" for Gluconeogenesis? Answer: The primary non-carbohydrate precursors are **Lactate** (from muscles), **Glycerol** (from fat breakdown), and **Glucogenic Amino Acids** (from protein breakdown).

Q6: How does Insulin affect carbohydrate metabolism? Answer: Insulin promotes the uptake of glucose by cells, increases the rate of **Glycolysis** (burning sugar), and stimulates **Glycogenesis** (storing sugar), while inhibiting glucose-producing pathways like gluconeogenesis.

Q7: What is the significance of the liver in carbohydrate metabolism? Answer: The liver acts as a "Glucose Buffer."It stores glucose when levels are high and produces/releases glucose (via glycogenolysis or gluconeogenesis) when blood levels are low to maintain homeostasis.

Q8: What is the byproduct of glucose metabolism that must be monitored in respiratory patients? Answer: The byproduct is **Carbon Dioxide (CO_2)**. In patients with respiratory failure (like COPD), high carbohydrate intake can increase CO_2 production, making it harder for the patient to breathe or wean off a ventilator.

Q9: Explain the relationship between Glycolysis and the Citric Acid Cycle. Answer: Glycolysis occurs in the cytoplasm and breaks glucose into pyruvate. Pyruvate then moves into the mitochondria, is converted to Acetyl-CoA, and enters the Citric Acid Cycle for further energy extraction.

Unit XI: Metabolism of Fats

Unit Objectives:

1. Explain the metabolism of fats
2. Describe the oxidation mechanism of fatty acids.
3. Discuss the amount of energy produced during the oxidation of a fat.
4. Explain the significance of the role of ketone bodies.

Metabolism of Fats

Fat metabolism involves the processes of synthesis (**Lipogenesis**) and breakdown (**Lipolysis**).

- **Digestion and Absorption:** Dietary fats are broken down into fatty acids and glycerol by lipase. They are transported in the blood via lipoproteins (chylomicrons, LDL, HDL).
- **Lipolysis:** When energy is needed, triglycerides in adipose tissue are broken down into glycerol and fatty acids.
- **Glycerol Pathway:** Glycerol enters the carbohydrate pathway (glycolysis) to produce energy.
- **Fatty Acid Pathway:** Fatty acids are transported into the mitochondria for oxidation.

Oxidation Mechanism: Beta-Oxidation

The primary mechanism for breaking down fatty acids is **β-Oxidation**. This occurs inside the **mitochondria**.

- **Activation:** The fatty acid is activated in the cytosol to form Fatty Acyl-CoA.
- **Transport:** It is carried across the mitochondrial membrane by the **Carnitine shuttle**.
- **The Process:** The fatty acid chain is broken down two carbons at a time. Each "cycle" of β-oxidation produces:
    1. **Acetyl-CoA** (which enters the Citric Acid Cycle).
    2. **NADH and FADH2** (which go to the Electron Transport Chain).

Energy Production from Fat Oxidation

Fats provide significantly more energy than carbohydrates (9 kcal/g vs. 4 kcal/g).

- **ATP Yield:** The total ATP depends on the length of the fatty acid chain. For example, the oxidation of one molecule of **Palmitic acid** (a 16-carbon fatty acid) yields a net total of **129 ATP**.
- **Comparison:** One molecule of glucose yields only **30–32 ATP**. This is why fats are the body's preferred long-term energy storage.

Significance of Ketone Bodies

When fat breakdown is very rapid (starvation, low-carb diets, or uncontrolled diabetes), the liver produces **Ketone Bodies**(Acetone, Acetoacetate, and β-hydroxybutyrate).

- **Biological Role:** They serve as an alternative fuel for the heart and brain when glucose is scarce.
- **Clinical Significance (Ketosis vs. Ketoacidosis):**
  - **Ketosis:** A normal metabolic state where the body uses ketones for fuel.
  - **Ketoacidosis (DKA):** A dangerous medical emergency (often in Type 1 Diabetes) where ketone levels are so high that blood pH drops below 7.35, leading to coma or death.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	The primary site for β-oxidation is the:	Ribosome	**Mitochondria**	Cytoplasm	Golgi Body	**B**
2	How much energy is produced by 1g of fat?	4 kcal	7 kcal	**9 kcal**	2 kcal	**C**
3	Which molecule carries fatty acids into mitochondria?	Insulin	**Carnitine**	Glucose	Hemoglobin	**B**
4	The breakdown of a 16-carbon palmitic acid yields:	32 ATP	10 ATP	**129 ATP**	2 ATP	**C**
5	Ketone bodies are primarily synthesized in the:	Muscles	**Liver**	Kidneys	Brain	**B**
6	Which of these is a ketone body?	Glucose	Urea	**Acetone**	Pyruvate	**C**
7	β-oxidation breaks fatty acids into units of:	1 Carbon	**2 Carbons**	4 Carbons	6 Carbons	**B**
8	Excessive ketone production in diabetics leads to:	Alkalosis	**Acidosis**	Hypertension	Hypoxia	**B**
9	The process of creating new fats is called:	Lipolysis	**Lipogenesis**	Glycolysis	Ketosis	**B**
10	Lipids are transported in the blood as:	**Lipoproteins**	Amino acids	Monosaccharides	Minerals	**A**
11	The final product of each β-oxidation cycle is:	Oxygen	**Acetyl-CoA**	Lactate	Carbon	**B**

Sr. No	Question	Option A	Option B	Option C	Option D	
12	During starvation, the brain uses _____ for energy.	Glucose only	**Ketone bodies**	Fatty acids	Proteins	**B**
13	Triglycerides consist of fatty acids and:	Glucose	**Glycerol**	Amino acids	Phosphate	**B**
14	β-hydroxybutyrate is a type of:	Sugar	Enzyme	**Ketone body**	Vitamin	**C**
15	Fat oxidation requires more _____ than carb oxidation.	Nitrogen	**Oxygen**	Water	Carbon	**B**
16	Lipase is an enzyme that digests:	Sugars	**Fats**	Proteins	DNA	**B**
17	Bile salts help in fat metabolism by:	Oxidation	**Emulsification**	Reduction	Hydration	**B**
18	High levels of ketones in the urine is called:	Glycosuria	**Ketonuria**	Proteinuria	Hematuria	**B**
19	Fatty acids are stored in the body as:	Glycogen	**Triglycerides**	Starch	Cholesterol	**B**
20	Which hormone promotes lipolysis (fat breakdown)?	Insulin	**Glucagon**	Estrogen	Melatonin	**B**

Part 2: Short Questions (SQs)

Q1: Define β-Oxidation and where it occurs. Answer: β-Oxidation is the metabolic process by which fatty acid molecules are broken down in the mitochondria to generate Acetyl-CoA, which then enters the Citric Acid Cycle to produce energy (ATP).

Q2: Why do fats provide more energy than carbohydrates? Answer: Fats are more "reduced" than carbohydrates, meaning they have a higher proportion of Carbon-Hydrogen bonds. When these bonds are oxidized, they release more electrons to the Electron Transport Chain, resulting in a much higher yield of ATP per gram.

Q3: What are the three main Ketone Bodies? Answer: The three ketone bodies are **Acetoacetate**, **β-hydroxybutyrate**, and **Acetone**.

Q4: Explain the role of the "Carnitine Shuttle." Answer: Fatty acids cannot cross the inner mitochondrial membrane on their own. The Carnitine shuttle is a transport mechanism that carries long-chain fatty acids into the mitochondrial matrix so β-oxidation can take place.

Q5: What is the clinical significance of Diabetic Ketoacidosis (DKA)? Answer: DKA occurs when a lack of insulin causes the body to burn fat too rapidly, leading to a massive buildup of acidic ketone bodies. This lowers blood pH, causing metabolic acidosis, which is life-threatening and requires immediate insulin and fluid therapy.

Q6: What happens to Glycerol during fat metabolism? Answer: Glycerol is converted into Glyceraldehyde-3-phosphate. It can then either enter **Glycolysis** to be burned for energy or be used in **Gluconeogenesis** to create glucose.

Q7: How does the body use ketone bodies during starvation? Answer: During starvation, glucose levels are low. The liver produces ketone bodies from fat stores and exports them to the blood. The brain and heart can convert these ketones back into Acetyl-CoA to generate ATP, preserving vital functions.

Q8: Define Lipogenesis and Lipolysis. Answer: Lipogenesis is the synthesis of fatty acids and triglycerides (usually from excess glucose). **Lipolysis** is the breakdown of stored triglycerides into free fatty acids and glycerol when the body needs energy.

Q9: Why is Acetone sometimes detectable on a patient's breath? Answer: Acetone is a volatile ketone body. When levels are high (as in DKA or severe starvation), it is excreted through the lungs, giving the patient's breath a characteristic "fruity" or "sweet" smell.

Q10: What is the relationship between β-Oxidation and the Citric Acid Cycle? Answer: β-Oxidation produces **Acetyl-CoA** from fatty acids. This Acetyl-CoA then enters the Citric Acid Cycle, where it is further oxidized to produce the NADH and FADH2 necessary for large-scale ATP production.

Unit X: Metabolism of Protein

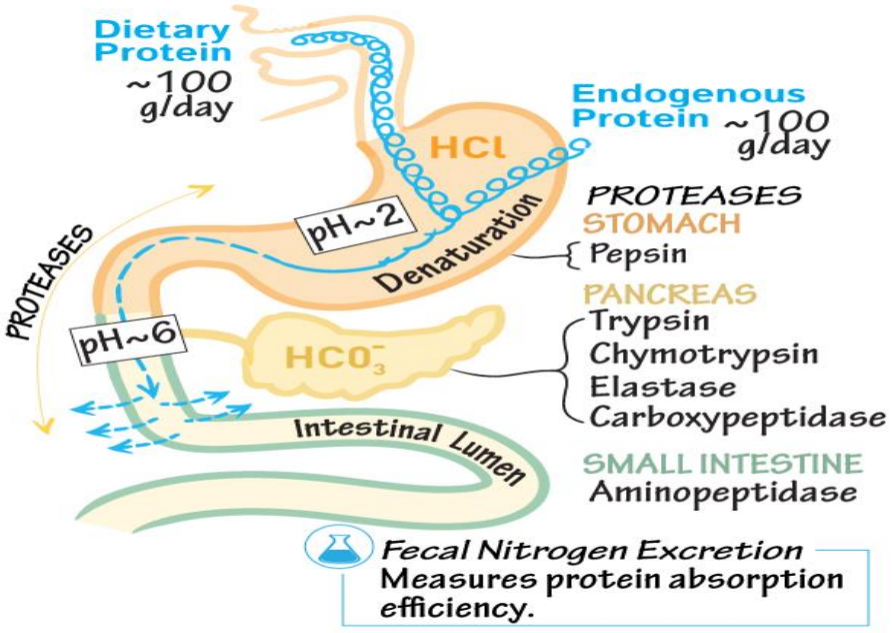
Unit Objectives:

1. Explain the metabolism of Proteins
2. Review the digestion and absorption of protein.
3. Explain the significance of nitrogen balance.
4. Describe the synthesis of protein.
5. Discuss the transamination, deamination and decarboxylation.
6. Discuss the formation of urea and ammonia disposal.

1. Digestion and Absorption of Protein

The body cannot absorb intact proteins; they must be broken down into individual **amino acids**.

- **Stomach:** Digestion begins here with **Pepsin** and Hydrochloric acid (HCl), which denatures proteins and breaks them into smaller polypeptides.
- **Small Intestine:** Enzymes from the pancreas (Trypsin, Chymotrypsin) and the intestinal wall (Peptidases) break peptides into tripeptides, dipeptides, and single amino acids.
- **Absorption:** Amino acids are absorbed into the blood through the intestinal wall and transported to the **Liver** via the portal vein.



2. Nitrogen Balance

Since proteins contain nitrogen (which carbs and fats do not), we measure protein metabolism through **Nitrogen Balance**.

- **Positive Nitrogen Balance:** Intake > Excretion. Occurs during growth, pregnancy, and recovery from injury (tissue building).
- **Negative Nitrogen Balance:** Excretion > Intake. Occurs during starvation, severe burns, fever, or wasting diseases (tissue breakdown).
- **Equilibrium:** Intake = Excretion. Seen in healthy adults.

3. Protein Synthesis

This is the "Anabolism" of proteins, occurring in the **Ribosomes** of cells.

- **Transcription:** The DNA code is copied onto mRNA in the nucleus.
- **Translation:** Ribosomes read the mRNA code and link amino acids (brought by tRNA) in a specific sequence to form a protein.

4. Transamination, Deamination, and Decarboxylation

These are the three primary chemical reactions used to handle amino acids:

- **Transamination:** The transfer of an amino group (−NH2) from an amino acid to a keto acid to create a *new* amino acid. This is how the body makes non-essential amino acids.
- **Deamination:** The *removal* of the amino group from an amino acid. The remaining "carbon skeleton" is used for energy, while the removed nitrogen becomes **Ammonia**.
- **Decarboxylation:** The removal of a carboxyl group (−COOH) from an amino acid. This process often produces physiologically active amines (like Histamine or Serotonine).

5. Urea Formation and Ammonia Disposal

Ammonia (NH3) produced during deamination is highly toxic, especially to the brain.

- **Ammonia Disposal:** The liver quickly converts toxic ammonia into **Urea**, which is non-toxic and water-soluble.
- **The Urea Cycle:** This occurs exclusively in the **Liver**.
- **Excretion:** Urea enters the blood and is filtered by the **Kidneys**, then excreted in urine.
    - *Clinical Note:* If the liver fails, ammonia builds up (causing hepatic encephalopathy). If the kidneys fail, urea builds up (measured as high BUN - Blood Urea Nitrogen).

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	
1	Protein digestion begins in the:	Mouth	**Stomach**	Large Intestine	Liver	**B**
2	Which enzyme is primary for protein digestion in the stomach?	Amylase	Lipase	**Pepsin**	Lactase	**C**
3	A pregnant woman is likely in:	**Positive N-Balance**	Negative N-Balance	Equilibrium	Ketosis	**A**
4	The transfer of an amino group to form a new amino acid is:	Deamination	**Transamination**	Decarboxylation	Oxidation	**B**
5	Ammonia is converted into Urea in the:	Kidneys	**Liver**	Brain	Muscles	**B**
6	Which nitrogenous waste is measured to check kidney function?	Ammonia	**Urea (BUN)**	Uric Acid	Amino Acids	**B**
7	The removal of a carboxyl group is called:	Deamination	Transamination	**Decarboxylation**	Hydrogenation	**C**
8	Negative Nitrogen Balance is seen in:	Growth	Pregnancy	**Starvation**	Bodybuilding	**C**
9	Proteins are synthesized on which cell organelle?	Mitochondria	**Ribosomes**	Lysosomes	Golgi	**B**
10	High blood ammonia levels primarily affect the:	Heart	**Brain**	Bones	Skin	**B**
11	Transcription occurs in the:	**Nucleus**	Cytoplasm	Ribosome	Cell Wall	**A**

Sr. No	Question	Option A	Option B	Option C	Option D	
12	Deamination involves the removal of which group?	Carboxyl	**Amino**	Hydroxyl	Phosphate	**B**
13	Amino acids are linked together by _____ bonds.	Ionic	**Peptide**	Glycosidic	Hydrogen	**B**
14	Which vitamin derivative is often a co-factor in transamination?	Vitamin C	**Vitamin B6**	Vitamin D	Vitamin K	**B**
15	The primary site of amino acid absorption is the:	Stomach	**Small Intestine**	Esophagus	Colon	**B**
16	Urea is excreted from the body via:	Lungs	Skin	**Kidneys**	Liver	**C**
17	Synthesis of mRNA from DNA is called:	**Transcription**	Translation	Replication	Mutation	**A**
18	"Keto acids" are the result of which process?	**Deamination**	Decarboxylation	Glycolysis	Lipolysis	**A**
19	A patient with severe burns will be in:	Positive N-Balance	**Negative N-Balance**	Equilibrium	Hyperglycemia	**B**
20	Non-essential amino acids are made via:	**Transamination**	Deamination	Filtration	Digestion	**A**

Part 2: Short Questions (SQs)

Q1: Explain the difference between Positive and Negative Nitrogen Balance. Answer: Positive Nitrogen Balanceoccurs when nitrogen intake exceeds excretion, indicating the body is building tissue (e.g., growth, pregnancy). **Negative Nitrogen Balance** occurs when excretion exceeds intake, indicating tissue breakdown (e.g., starvation, severe infection, or trauma).

Q2: Describe the role of the Liver in protein metabolism. Answer: The liver is the central hub for protein metabolism.It synthesizes plasma proteins (like albumin), performs transamination to make new amino acids, and converts toxic ammonia into urea through the urea cycle.

Q3: What is the clinical significance of high blood ammonia levels? Answer: Ammonia is a toxic byproduct of protein catabolism. If the liver cannot convert it to urea (as in cirrhosis), ammonia levels rise and cross the blood-brain barrier, leading to **Hepatic Encephalopathy**, characterized by confusion, tremors, and coma.

Q4: Briefly explain Transamination. Answer: Transamination is a chemical reaction where an amino group from an amino acid is transferred to a keto acid. This process allows the body to synthesize non-essential amino acids from intermediate metabolic products.

Q5: What is Deamination and why is it necessary? Answer: Deamination is the removal of the amino group from an amino acid. It is necessary when the body needs to use the carbon skeleton of the amino acid for energy (ATP) or to convert it into glucose/fat.

Q6: What happens during the "Translation" phase of protein synthesis? Answer: Translation occurs in the ribosomes. The mRNA sequence is "read," and tRNA molecules bring the corresponding amino acids to the ribosome, where they are linked together by peptide bonds to form a protein chain.

Q7: Why is Urea better for the body than Ammonia? Answer: Ammonia is highly toxic and alkaline, which can damage cells (especially neurons). Urea is a neutral, non-toxic molecule that is highly soluble in water, making it safe to transport in the blood and easy for the kidneys to excrete.

Q8: What is Decarboxylation and give a clinical example? Answer: Decarboxylation is the removal of a carbon dioxide molecule from an amino acid. An example is the conversion of Histidine into **Histamine**, which is a key mediator in allergic reactions and inflammation.

Q9: Identify the enzymes involved in protein digestion in the small intestine. Answer: Pancreatic enzymes like **Trypsin**, **Chymotrypsin**, and **Carboxypeptidase** are released into the small intestine to break down large polypeptides into smaller peptides and individual amino acids.

Q10: Why do patients with kidney failure have high BUN (Blood Urea Nitrogen) levels? Answer: Urea is produced by the liver and filtered out of the blood by the kidneys. If the kidneys are not functioning properly, they cannot filter the urea, causing it to accumulate in the blood.

Unit XI: Hormones (Communication among cells & tissue)

Unit Objectives:

1. Describe hormones and the body"s feedback mechanism.
2. Describes the classification of hormone.
3. Discuss the mode and function of steroid & peptides hormones.
4. Identify the cardiac, pineal, and gastrointestinal hormones.

1. Hormones and Feedback Mechanisms

Hormones are chemical substances secreted by endocrine glands directly into the blood to regulate the activities of specific target cells or organs.

The Feedback Mechanism

The body regulates hormone levels primarily through **Negative Feedback**.

- **Negative Feedback:** When the level of a hormone or its effect reaches a certain threshold, the body sends a signal to *stop* further secretion.
    - *Example:* High blood glucose triggers insulin. Once glucose drops, insulin secretion is inhibited.
- **Positive Feedback:** A change triggers *more* of the same response (less common).
    - *Example:* Oxytocin secretion during labor—contractions trigger more oxytocin until the baby is born.

2. Classification of Hormones

Hormones are generally classified based on their chemical structure:

1. **Peptide/Protein Hormones:** Chains of amino acids. They are water-soluble (e.g., Insulin, Glucagon, Growth Hormone).
2. **Steroid Hormones:** Derived from **Cholesterol**. They are lipid-soluble (e.g., Cortisol, Testosterone, Estrogen).
3. **Amino Acid Derivatives:** Small molecules derived from single amino acids like Tyrosine (e.g., Epinephrine, Thyroid hormones).

3. Mode and Function: Steroid vs. Peptide

Because of their chemical nature, these two types of hormones interact with cells differently:

Feature	Peptide Hormones	Steroid Hormones

Solubility	Water-soluble (Polar).	Lipid-soluble (Non-polar).
Receptor Location	On the **Cell Surface** (Membrane).	**Inside the cell** (Cytoplasm or Nucleus).
Mechanism	Use "Second Messengers" (like cAMP).	Directly affect **Gene Transcription**.
Speed of Action	Fast/Immediate.	Slower (minutes to hours).

4. Specific Hormones: Cardiac, Pineal, and GI

Not all hormones come from traditional glands like the Pituitary or Thyroid.

- **Cardiac Hormones:** The heart (Atria) secretes **Atrial Natriuretic Peptide (ANP)**. It helps lower blood pressure by promoting salt and water excretion by the kidneys.
- **Pineal Hormone:** The pineal gland in the brain secretes **Melatonin**, which regulates the sleep-wake cycle (circadian rhythm).
- **Gastrointestinal (GI) Hormones:**
  - **Gastrin:** Stimulates gastric acid secretion.
  - **Secretin:** Stimulates the pancreas to release bicarbonate.
  - **Cholecystokinin (CCK):** Stimulates the gallbladder to release bile and the pancreas to release enzymes.

Part 1: Multiple Choice Questions (MCQs)

Sr. No	Question	Option A	Option B	Option C	Option D	Correct Answer
1	Most hormone regulation occurs via:	Positive Feedback	**Negative Feedback**	Neutral Feedback	No Feedback	**B**

2	Steroid hormones are derived from:	Proteins	**Cholesterol**	Sugars	Amino acids	**B**
3	Where are receptors for Peptide hormones located?	Nucleus	Cytoplasm	**Cell Membrane**	Mitochondria	**C**
4	Which hormone is secreted by the Atria of the heart?	Insulin	**ANP**	Melatonin	Gastrin	**B**
5	Melatonin is produced by which gland?	Thyroid	**Pineal**	Adrenal	Pituitary	**B**
6	Which of the following is a lipid-soluble hormone?	Insulin	**Cortisol**	Glucagon	Epinephrine	**B**
7	Second messengers (like cAMP) are used by:	**Peptide hormones**	Steroid hormones	Vitamins	Minerals	**A**
8	Which GI hormone stimulates gallbladder contraction?	Gastrin	Secretin	**CCK**	Insulin	**C**
9	Thyroid hormones (T3/T4) are derived from:	**Tyrosine**	Cholesterol	Fatty acids	Glucose	**A**
10	Positive feedback is seen during:	Blood sugar control	**Labor (Childbirth)**	Cooling the body	Sleep	**B**
11	ANP helps the body to:	Increase BP	**Decrease BP**	Increase Sugar	Decrease Sugar	**B**
12	Steroid hormones primarily affect:	Cell permeability	**Gene expression**	Ion channels	Water intake	**B**
13	Which hormone regulates the sleep-wake cycle?	Cortisol	**Melatonin**	Thyroxine	ADH	**B**

14	Gastrin is primarily involved in:	**Acid secretion**	Bile release	Sleep	Growth	**A**
15	Insulin and Glucagon are examples of:	Steroid hormones	**Peptide hormones**	Amino derivatives	Lipids	**B**
16	Receptors for steroid hormones are found in:	**Nucleus/Cytosol**	Cell wall	Blood plasma	Ribosomes	**A**
17	Which hormone is released in response to high stress?	**Cortisol**	Melatonin	Gastrin	ANP	**A**
18	Cholecystokinin (CCK) is produced in the:	Stomach	**Small Intestine**	Liver	Heart	**B**
19	The "Master Gland" that controls other glands is:	Thyroid	**Pituitary**	Pineal	Pancreas	**B**
20	Water-soluble hormones travel _____ in the blood.	Attached to proteins	**Freely**	Inside RBCs	In air bubbles	**B**

Part 2: Short Questions (SQs)

Q1: Define Hormone and its primary method of transport.

Answer: A hormone is a chemical signaling molecule produced by endocrine glands that travels through the **bloodstream** to reach and regulate distant target organs or tissues.

Q2: How does Negative Feedback maintain homeostasis?

Answer: Negative feedback works by reversing a change in the body. When a hormone level rises too high, the system detects this and inhibits further production, bringing the level back to its normal set point.

Q3: Explain the difference between Peptide and Steroid hormone receptors.

Answer: Peptide hormones are water-soluble and cannot cross the cell membrane, so their receptors are on the **cell surface**. Steroid hormones are lipid-soluble and pass through the membrane, so their receptors are located **inside the cell** (cytoplasm or nucleus).

Q4: What is the clinical significance of Atrial Natriuretic Peptide (ANP)?

Answer: ANP is a cardiac hormone released when the heart walls are stretched (due to high blood volume). It acts on the kidneys to increase sodium and water excretion, thereby reducing blood volume and blood pressure.

Q5: Describe the role of Melatonin.

Answer: Melatonin is secreted by the pineal gland. Its primary role is to regulate the body's **circadian rhythm** (internal clock), signaling the body that it is time to sleep when light levels are low.

Q6: Name three GI hormones and their functions.

Answer: 1. **Gastrin:** Increases stomach acid. 2. **Secretin:**Stimulates bicarbonate release to neutralize acid. 3. **CCK:** Stimulates bile release and pancreatic enzyme secretion.

Q7: Why do steroid hormones take longer to show an effect compared to peptide hormones?

Answer: Steroid hormones work by entering the nucleus and changing **gene expression** (making new proteins), which takes time. Peptide hormones activate existing enzymes via second messengers, which happens almost instantly.

Q8: Give an example of a Positive Feedback mechanism.

Answer: During childbirth, the hormone **Oxytocin** causes uterine contractions. These contractions signal the brain to release *more* oxytocin, which causes even stronger contractions. This loop continues until the baby is delivered.

Q9: What is the "Second Messenger" system?

Answer: It is a method used by water-soluble (peptide) hormones. Since the hormone cannot enter the cell, it binds to a surface receptor, which triggers a molecule inside the cell (like **cAMP**) to carry out the hormone's instructions.

Q10: Why is cholesterol important for the endocrine system?

Answer: Cholesterol is the essential precursor (starting material) for all **steroid hormones**, including cortisol, aldosterone, estrogen, and testosterone. Without cholesterol, these vital hormones cannot be produced.